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FACTUAL MATERIAL IN EARLY CHILDHOOD EDUCATION

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To write an article from a "mental hygiene" point of view is almost like throwing oneself into the mouth of a dragon, as the meaning of mental hygiene has become so ambiguous. This is due to its use by people either too psychoanalytical or inexperienced in the field of abnormal psychology.

In spite of the misunderstanding of the function of the mental hygienist, I feel sure there is a place for mental hygiene in all of our schools. It should function as a basis for understanding normal mind action and not for seeking symptoms of insanity. Mental hygienists, it seems to me, should be capable of seeing all school activities realistically and in relation to the child's present needs. Therefore, his place in the school should be definitely on the teaching staff with a definite subject he can teach well, at the same time understanding all subject matter, but in particular those in applicable form toward life values.

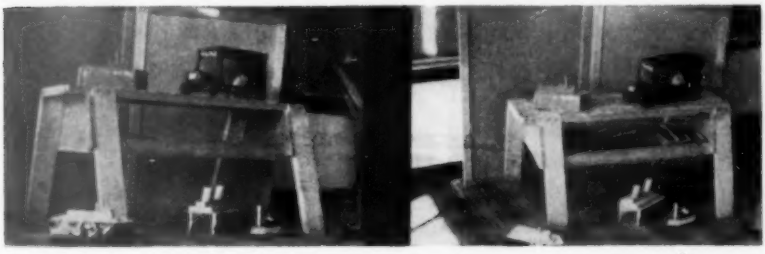
Landor states: "We are on earth to learn what can be learnt upon earth, and not to speculate on what can never be. Let men learn what benefits men; above all things to contract their wishes, to calm their passions, and, more especially, to dispel their fears. Now these are to be dispelled, not by collecting clouds, but by piercing and scattering them. Much of what we call sublime is only the residue of infancy, and the worst of it."

I think we can today truthfully begin to question whether education is functioning or not. Having had a varied experience at different, so-called social levels and having worked for many

years with the so-called, insane, I have felt at times that education, as it is being applied, did not and does not produce results anticipated. It is easy to question but hard to suggest a solution. I do believe we will have to provide one soon or something drastic and serious, in the structure of man's relationships, will happen. The word education, as it is explained in the dictionary, is the systematic development and cultivation of the natural powers by inculcation and example. In applying this meaning to the child's needs we must learn to know by which instrument the child is learning. I may incidentally say here that learning is not easy. If we try to make it so, we may defeat learning itself. Also, may I say that to make things easy does not necessarily make them interesting. I do not think that you can apply what is sometimes called "the play way." The instruments by which the child learns are ready for development at birth but are not developed. As long as the human body is growing, may we not say that every part of this body is under development and is in constant need of every opportunity for that purpose? Let us take the eye in its growth and development. Call it an instrument of perception. Its growth is normal; the individual has no control over it, but its capacity to see objects in their true relationship is developed as it needs to associate facts. This development is impossible without paying strict attention to obvious elements. We do not see fairies, but by illusion we may think we do.

Let us, for example, use a child's experience in construction, which is my job. He has been observing boats or airplanes. He is in the second grade. He has seen a boat in the harbor. Because of its possibilities, he looked at this object longer than he would another thing. He has probably been on the boat or may have had experiences in rough weather; therefore, his interest is keener than most children's. But I have found that even without experiences on boats, most children have an interest in them. There is something in the relationship of the parts of most boats that is very challenging to the child's mind. A child wants to make a boat, or it may be a truck and his recollections of his observation are very definite, but in reality not quite true. These recollections must be tested, not by words or other forms of illustrations, but by the actual structure. This can only be done by using mathematical formulas. Many children, perhaps hundreds of them, have come to me and said, "I want to make a boat." I ask, "How long?" They say, "About so long," holding

their hands a certain distance apart. Here, I think, is a good chance to teach reality. It is a certain number of inches or feet or it is not. Therefore, we should tell the children there isn't any "about," it is a certain thing or it isn't. Then if the child says, after actually measuring the thing, that it is to be fifteen inches long, he necessarily must decide how wide. This being a second grade child, drawing by scale is a little out of order. But when he observed the boat in the harbor he saw certain symmetrical relationships, and I know from experience that children see those symmetrical relationships better than we think they do. The symmetrical relationship may become confused if the child is merely to repeat verbally what he has seen, while if he is to measure and compute by use of material in construction of a boat, he



will know that a fifteen-inch long replica can't be fifteen inches wide, as the boat he saw was not square. Now his visual experience in observing the boat has to be verified by number technique in order to become convincing. This conviction, arrived at because of measurement, is of the intellect, as he can always check back and prove his point; while the verbal illustration of his boat observation is of the emotion and may be in contradiction with other verbal illustrations of observation. Great arguments can be brought about without any definite conclusion.

Personally, I think that all of our complications in civilization are due to our inability to see clearly the relationship needed for all in our human life. We feel more than we see, and feelings can easily be hurt while factual observations are the same to all men. And anyone with ordinary intelligence seeking for truths in life will find an answer to his questions.

My point of view in regard to the value of measurements was again definitely illustrated by a group of boys, from the ages of seven to fourteen, at a farm camp where interest predominated as a driving force for activity. A project was started on the banks of the creek by one of the younger boys. Before he had

worked very long several boys began to want a similar experience. Since there was not enough space for all on the creek front, some had to take plots of ground removed from the creek. The fact that some had no waterfront led to complications, as the whole idea was to make boats that would float down stream toward a landing place. This landing place had been built into a harbor for unloading stones and other things that could be piled upon a boat. The boats were made so that the force of the stream would keep them directed toward this point; that is, they had to have a rudder set in a certain position and of a certain length in order to follow the stream without turning. This was worked out mathematically by a ruler, so the boats were practically all similar in size but not in form. Yet the symmetry of them was nearly accurate. The interesting part to me was the social value of that project as more and more of the boys wanted to participate.

The picture shows two-thirds of the group working on a sunny day at a temperature of ninety-two degrees. As was said before, a number of the boys had to have plots of ground away from the waterfront; therefore, they worked out a canal system in which all properties were touched, so each one could anchor his boat and load for transport to the community harbor. Later on, islands were built in the creek for more distant transportation. Before anyone realized it, there was a genuine community project with law and order. There were discussions frequently about construction and better methods of making boats. Help was given by an adult so that the project became progressive in its totality and tinkering was avoided. May I incidentally say here that frequently interest of projects and interest of making is turned into tinkering rather than construction? A teacher is necessary in all situations to bring the child's attention to the necessity of orderliness in his ideas and completion of them. This project lasted for twelve days and during that time a number of very specific things were made, such as docks, boats and derricks for hoisting. Everything was worked out carefully with a sustained interest because of the purpose being a complete experience. I always like to think of a small chapter from Epictitus' *Discourses*. He says: "Today I choose to play. Well then, ought you not to play with attention? I choose to sing. What then hinders you from doing so with attention? Is there any part of life excepted, to which attention does not extend? For will you do it worse by using attention, and better by not

attending at all? And what else of things in life is done better by those who do not use attention? Does he who works in woodwork do better by not attending to it? Does the captain of a ship manage it better by not attending? And is any of the smaller acts done better by inattention? Do you not see that when you have let your mind loose, it is no longer in your power to recall it, either to propriety, or to modesty, or to moderation: but you do everything that comes into your mind in obedience to your inclinations?"

Oftentimes we have to help the child to attend to his business because there are so many disturbing influences to distract his attention. But we can not do it with just words. We can do it much better, I can truthfully say, by helping the child to see clearly the way to approach his goal. I find an interesting statement in *Science and Sanity* by Korzybski. "From a functional or actional and semantic point of view, measurement represents nothing else but a search for empirical structure by means of extensional, ordered, symmetrical and asymmetrical relations.

Thus when we say that a given length measures five feet we have reached this conclusion by selecting a unit called 'foot,' an arbitrary and unspeakable affair, then laying it end to end five times in a definite extentional order and so have established the asymmetrical, and, in each case, a unique and specific relation that the given entity represents, in this case, five times as many as the arbitrarily selected unit idea."

The following picture is exactly what I have seen in a second grade work period at the National College of Education. Two boats are worked out by very careful analysis of the material available and the idea in mind. It has been most fascinating to me because I have seen evidence of logic in the children's effort toward attaining an objective. Rulers, saws, hammers,

try-squares and material, no complicated scrolling, just straight lines were used. To me it is very sad when we let the child make things without helping him to discover the secret of true relationships. In other words, some children, if left alone, will never discover it at all; they are likely to just tinker with material, and all tinkering and, so-called, "horse play" leaves an irritated child who, because of his nervousness, may get into complicated trouble with his classmates. On the contrary, if he succeeds because of logical analysis, of which children are capable much earlier in life than we give them credit for, he will develop a definite restfulness and calmness that makes him ready for what is coming next. Working with children both in the shop and on the playground, I can tell on the playground when they have had a good period of constructive thinking. If they have been busy and attentive in class they come out with a definite release in emotion and physical being, but they are also ready for activities that are somewhat orderly. They come with an idea of form in play, something that is a continual challenge to their concept of proportion. While if the preceding class has been restless, with much inattentiveness, the immediate

play response is "horse play," just disorderly attacking, throwing down, chasing without their being able to say why or wherefore.

There is a purpose in play. First of all it is physical in release of tension. It is emotional because of the feeling related to the coming struggle in activities against each other, and it is intellectual because of orderly procedure to obtain that goal. This orderly process makes for sanity and, as a mental hygienist, I feel that today we are too much interested in how we can get the child to *want* rather than to know *why*. We use many different techniques to get him to *want to do* without giving him the chance to consider the *why to do* and *how* an idea of construction is to be completed because of an orderly procedure involving logical tools, logical material and logical thinking. A book that I much appreciate is *Straight and Crooked Thinking* by Thouless. A student came to me the other day after having read the book. She was very much disturbed because she said the only way to approach life, according to Dr. Thouless, would be the scientific way. I asked her what was wrong with that and she said, "It leaves out all beauty." I tried to point out that it would bring beauty back to its relation to reality rather than continue vague emotional concepts of what beauty should be and much talk developing illusions as if they were real. All children are—now I am probably wrong in saying all; therefore, let's say, most children are—realists. Therefore, let them be educated to see beauty in real things which may become theirs through an orderly process of learning. But if they are not so educated, they will be constructing beauties within the mind—perhaps unreal ones—which only they appreciate.

May I give an instance here again from experience in collecting insects? In a group of twenty-two boys having the pleasure of intensive study of zoology, astronomy and entomology, a larger per cent was interested in collecting butterflies and moths. One boy who was particularly interested in collecting wasps found eighteen different kinds in the community. After the boys learned to master the technique of handling a net so that the specie caught wasn't destroyed or injured, and of taking out the insect and mounting it so the spread of the wings appeared normal, they studied the habitation and conditions necessary for the insect's existence. Understanding butterflies and moths and their relationships to other living organisms and putting all this in intelligent form means clean perception of beauty in

reality. So it was with the study of zoology. Several boys worked with two excellent powerful microscopes (I think the toy microscope should be discouraged), collecting their own material, making their own slides, shaping their observation into a definite study of relationship. All this had a definite effect upon the children's nature. They seemed to want to do things because there was a purpose and a very, very definite mode of attention. There was a constant challenge from nature itself to prove points, that in itself would necessarily make them more alert in developing techniques by which they could master the environment. The age range again was seven to fourteen and I was greatly astonished at the skill of the young child in learning to work toward his goals, reading scientific descriptions of the insects he had caught, finding out that he was not a very good reader at school. This was most revealing. Maybe we ought to begin to do some thorough research in the field of reading material. Again I feel that Korzybski and others, like Bridgman in his book, *The Meaning of Meaning*, are positively right that we talk too much without any definite relation to observable facts. Until we learn the relationship between the need of a clear ear capacity, eye capacity, mouth capacity and hand capacity, we are guessing too much in our education. The hand is handicapped unless the eye and ear perceive truth and beauty related to observable fact, and unless the meaning of what you see and not what you think you see is put into words. The possibilities of the hand are unknown as yet. We hope that in the future we will do more than hand the child paper, pencil and ruler. Let him have these, but give him also the material that he can shape according to mathematical science. Then number will not be a form of complexes but will be part of his equipment to draw out of the unknown qualities known qualities that can be checked and rechecked and proven to be factually so.

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A PHILOSOPHY FOR SCIENCE TEACHING*

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A discussion of my topic, A Philosophy for Science Teaching, calls at the outset for a definition and an explanation. The definition is of the term, philosophy; the explanation, of the article "a."

What is philosophy? Philosophy is sometimes thought of as the opposite of science; science as what we know, philosophy as what we do not know. Speculation upon the unknown; that is thought by many to be philosophy. Used in that sense, my topic would indeed be one at which teachers of science might well bridle because it would then bear the implication that nothing is known about how to teach science and therefore any discussion of science teaching is waste time. Needless to say, I do not accept such a definition of the term philosophy.

I would use the term philosophy as synonymous with the term *program;* a set of stated ways and means for achieving stated objectives. In this sense, the terms science and philosophy become supplementary rather than oppositional. I would hope to use all the knowledge I possess—my science—in the formulation of my statement of ends, ways, and means—my philosophy. A philosophy for science teaching then is a program for teaching science; perhaps the most vital and important matter a group of science teachers can well study or discuss.

So much for the definition. What of the explanation? You may have noted that I use the article "a," not "the," as a modifier for the term philosophy. I propose to discuss *a* philosophy; one out of many which might possibly be discussed. I do not presume to speak for all who might discuss this topic. I speak for myself only. I propose to discuss what I consider the *best* philosophy for science teaching, but I do not consider it the only one. Probably there are as many different philosophies for science teaching as there are people giving the matter conscious attention; many of them good, many not good. And, like the statement that there is only one best woman in the world and every married man thinks he has her (or, I presume, at least thought so at one time), so also I would presume that everyone

* This paper was read before the Department of Science Instruction of the N.E.A. at San Francisco in July, 1939.

who has taken the trouble to think out a philosophy for science teaching believes he has the best one. If I did not so believe, I would adopt—and, in fact, will adopt when I find it—the one which I find to be better, because, in a matter as important as this, one can afford to adopt nothing but the best.

A philosophy (or program) for teaching any subject—and please believe me when I say that I am not losing sight of the fact that I should be and am teaching children—a philosophy for teaching any subject must take into account three major factors. First, it should take into account the basic idealism of the society of which it is a part. In this country that basic idealism is democracy. Teachers in this country have a primary obligation to formulate and abide by a teaching program which is basically democratic. If and when we teach under a régime such as Hitler's or Mussolini's, then we should be authoritarian and dictatorial, but not in America—not yet, at any rate, and I hope not soon.

Democracy must be distinguished from the unequally limited freedom of autocracy on the one hand—greater freedom for the privileged than for the unprivileged—and from the unlimited freedom of *laissez faire* individualism on the other. Democracy implies certain limitations on individual freedom, such as speed limits for automobile drivers or prohibitions against personal assault. But such limitations under a truly democratic régime are applied equally to all, high as well as low. Democracy implies equality of freedom—equally limited freedom—and also its reciprocal, equally shared responsibilities.

As to arriving at and holding given beliefs, a teacher in a democratic society is not justified in saying to a pupil, "Thou shalt believe as I believe." That is autocratic authoritarianism. Nor, on the other hand, is a teacher justified in permitting pupils thoughtlessly to entertain any and all beliefs which their respective fancies of the moment may dictate. That is laissez faire individualism.

The democratic principle is that a pupil should be granted the same rights *and held to the same responsibilities* as other members of society, notably his teacher. With regard to arriving at and holding beliefs, those rights and responsibilities are two-fold: first, to take into account all data (facts and principles) which are pertinent and available; second, to reach conclusions which are in keeping with such data, as well as in keeping with other conclusions which the individual entertains. In other words,

self-agreement or *internal consistency*, on the broadest foundation of factual data suitable to the case in hand, forms the basis of guidance and criticism in keeping with the obligations of a teacher in a democratic society.

Shall a child be permitted to believe that earthworms rain from the sky? If, after all data understandable to him have been brought into the picture, his own mental processes point logically to such a conclusion, he should be permitted without further pressure to hold such a belief, at least until new data are introduced or he has reached a higher level of mental maturity. The chances, we know, in this case are largely against such an eventuality, but I purposely selected a preposterous case to exemplify the point. I do not believe we need to be overly concerned about a matter such as this, because pupils grow older continuously and with proper instruction are continually reconstructing their beliefs and behavior patterns. They believe in Santa Claus one year and the next year they do not; why then should teachers be overwrought when youngsters believe wrong things from time to time. Should a pupil not have as much right to be wrong as a teacher? Anyway, what can we do about it? What is it we say about "a man convinced against his will"? And, moreover, if a pupil is permitted without undue pressure to disagree with his teacher whenever his conscience so dictates, by that very fact the pupil also assumes the responsibility to defend his belief; a condition in itself highly educative for members of a democratic citizenry.

Second, a teaching philosophy should catch the basic spirit of the subject which is to be taught. We can think of science as a fund of dependable knowledge; a set of facts and principles which have been subjected to the searching test of scientific scrutiny and have been found satisfactory. But knowledge of the outcomes of scientific investigation, I suspect, does not represent the true genius of science.

A scientist is respected, not for the sum total of his knowledge, but rather for his ability to get knowledge; for the discoveries he has made and gives promise of making. In teaching science, therefore, I would want primarily to develop scientific mindedness on the part of students; scientific mindedness as a way of life, not as a relatively paltry set of laboratory techniques or isolated skills. As students learn the facts and principles inherent in the subject taught, they should be led to discern and embrace the method by which those facts and principles have come

into man's possession. In other words, each student should be led to arrive at an understanding of each scientific principle he studies much as did the scientific investigator who first discovered or formulated the principle; performing the thinking, not repeating more of the manipulative experimentation than is necessary to enable him to grasp the meaning of published accounts. In a very real sense, such procedure involves a study of the history of scientific discovery. Thus a student learns the method of science at the same time that he is learning the outcomes of scientific method, and scientific method gradually and progressively becomes a way of life—imbedded in the warp and woof of his thinking and acting—rather than becoming merely an additional trick or skill.

Third, a teaching philosophy should be fully cognizant of, and in keeping with, child psychology. A teacher should know the manner in which ideas form in the mind of a learner; should know the psychology of learning. He should conduct class in such a manner as to *follow the logic of a growing mind*. Psychological thought has undergone considerable change within the past fifteen or twenty years regarding the nature of learning. Of this fact most writers of textbooks on the teaching of science seem blissfully unaware. The view that learning is a "conditioning" or "stamping-in" process has pretty well given way to the view that learning is a process of developing insight; of discovering relationships between what we do and what consequences accrue therefrom. Goal-insight theory has pretty well replaced stimulus-response theory, and a teacher is advised by psychologists of the newer school to look well to interests, goals, and insights.

Without going into the justification for the newer view—our space is limited—I will merely state the three basic factors which the newer psychology claims must be taken into account in interpreting behavior, together with the rule by which one may predict behavior.

First, an individual acts because he craves or desires to achieve a goal; behavior is goal-seeking or purposive. Second, the individual acts in an environment made up of objects, many of which have possibilities of becoming aids or obstacles toward the achievement of the goal. Third, the individual possesses insights into the relations which the objects of his environment bear to the achievement of his goal. He comprehends some objects as helpful, others as hindrances, and still others as neutral.

Thus, the three factors which must be taken into account in interpreting behavior on the basis of the goal-insight theory are (1) goal, (2) environmental objects, and (3) insights.

Now, the rule which serves as the guide for predicting behavior on the basis of these three factors—we may call it the Principle of Least Action—is as follows: An individual will act in such a way as to achieve his goal in the quickest and easiest way he comprehends at the time. In other words, of whatever paths or ways to achieve a goal the individual knows, he will follow the quickest and easiest; the one involving the least expenditure of energy. Such, we say, is intelligent behavior.

From the foregoing, it would appear that a teacher of science in the United States is under obligation (a) to teach democratically, (b) to teach in such a way as to promote scientific mindedness, and (c) to teach in such a way as to stimulate the development of insight. If my data are inadequate or inaccurate, or if my logic is unsound, other conclusions may be indicated. If not, these conclusions hold.

Fortunately, it is not so difficult to achieve all three of these conditions in one's teaching as one might at first suspect, because they are all part and parcel of the same basic pattern. Scientific mindedness implies recourse to the scientific method of solving problems, and scientific method repeatedly has proven itself to be the most effectual method known to gain new and dependable insights regarding the world of which we are a part. Moreover, the method of science is *the* democratic way to gain new insights because it places responsibility equally upon all concerned in the conquest of the unknown. The fact that the two concepts—democracy and the scientific method—parallel one another closely in the chronology of their growth is more than an historical accident.

When it comes to the actual planning for a particular class, two major questions at once confront a teacher: First, what criterion shall be employed for choosing or selecting the subject matter to be studied? Second, what criterion shall be employed for choosing or selecting the manner in which the subject matter is to be studied? The former deals with curriculum, the latter with method.

Perhaps if we first state our covering-end for education, one which we believe is indicated by the conditions which we have been discussing, our discussion of criteria for choice of curriculum and method will then be more easily and clearly understood.

As a covering-end for education, we would seek to *stimulate a student toward becoming an independent learner* (a scientifically minded person), *while at the same time he is developing an enhanced and more harmonic outlook on life.* In answer to the question, "Is consideration of a pupil's outlook on life important for education?" I would be inclined to quote G. K. Chesterton's answer to a similar question, "Is anything else important?" The way one views the world of which he is a part determines his behavior with reference to this world, including his understandings, his skills, and his attitudes. What else is important?

We presume that a teacher should assist a pupil to study his Culture (his world, past and present), but with a view toward promoting its progressive refinement. The two adjectives above used to modify the phrase "outlook on life"—enhanced and harmonic—present a criterion for judging what constitutes refinement. We make bold to define refinement or improvement as increasing the number and scope of (enhancing), and systematizing or making mutually consistent (harmonizing), the factors which are under consideration at a given time.

In viewing our world for the purpose of making up our minds about it, we find this world considerably confused. Teachers try to develop scientifically justified beliefs on the part of pupils; politicians and the writers of newspaper and magazine advertisements try to tear them down. Parents want schools to be modern, yet they do not want pupils taught or handled differently than when the parents went to school.

Consequently, in selecting subject matter we should choose areas in which a pupil's knowledge is insufficient to satisfy his present desires, or in which his present ideas and beliefs are conflicting; preferably areas in which both these conditions exist. For example, along with Harvey's proposals that the movement of the blood is circulatory, I would want a student also to consider the Aristotelian explanation that movement is steadily outward from the liver through the veins, and the Galenic ebb-and-flow explanation. When a student in high school is ready for formal study of the method of science as a way of obtaining truth, I would want him also to consider the vitalistic method of obtaining truth by revelation and logical deduction, together with the materialistic method of mere observation. In the study of why organic species undergo change, I would want students to be faced with the conflicting theories of Lamarck, Darwin,

and DeVries, as well as with catastrophic theories such as that of divine creation.

Whether dangerous or not, the only way we can educate students is to give them repeated opportunities to comprehend and appreciate the manner in which the knowledge they are discovering is impinging upon and promising (or threatening) to remake the world. After all is said and done, I expect if we do not teach in such a way as somewhat to endanger our jobs, it is likely that we are not doing much of a job of teaching. Assuredly, we must be tactful and politic, but we cannot afford to be supine.

If we are to promote independent learners, we should confront pupils with problems challenging to them at their present condition of intellectual maturity, and lead them to formulate and test hypotheses scientifically so that they may reach scientifically justified conclusions. Justifiable conclusions are those which result from an enhanced knowledge of their world, and which harmonize the conflicting issues under consideration. Thus pupils become progressively more independent and self-reliant learners, and develop progressively enhanced and more harmonic outlooks on life—the covering-end which we have set for democratic education.

REMAGNETIZING BAR MAGNETS

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With continued use and abuse the ordinary laboratory bar magnets gradually lose their magnetism. To remagnetize them, a strong magnetic field is required. The following method was found to be very successful.

A power supply from an old radio or one of the formerly used "B" eliminators is used to provide the necessary direct current. The one used by me was the power supply from a Majestic Model 90. This provides 500 volts at 100 milliamperes and is a desirable piece of equipment for any physics laboratory. The solenoid I used was the speaker field coil from an 8″ dynamic speaker. Both of these items were bought from a local used radio shop for $1.00.

Insert a 5,000 ohm rheostat in series with the field coil to regulate the current. Determnie the direction of the magnetic field produced by the coil current so that the polarity of the bar magnets will remain unchanged. Then place the magnet in the center of the solenoid and turn on the current. Slight tapping of the magnets in the solenoid will aid the process. Five minutes is ample time for the magnets to remain in the core.

The elastic nature of a magnetic field can also be nicely demonstrated with this apparatus. A piece of clockspring about 4″ long is placed in the core. The spring is pulled to one side a few inches and then let go. It will vibrate back and forth just as if it were held by elastic bands.

A NOTE ON THE SKETCHING OF THE GENERAL PARABOLA

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The purpose of this note is to recall to teachers of analytic geometry a simple and accurate method of constructing the general parabola whose equation contains an xy term. A simple application of composition of ordinates replaces the usually unsatisfactory rotation of axes, without introducing any unfamiliar concepts.

Solution of the general equation of the parabola,

$$Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0 \tag{1}$$

for y gives

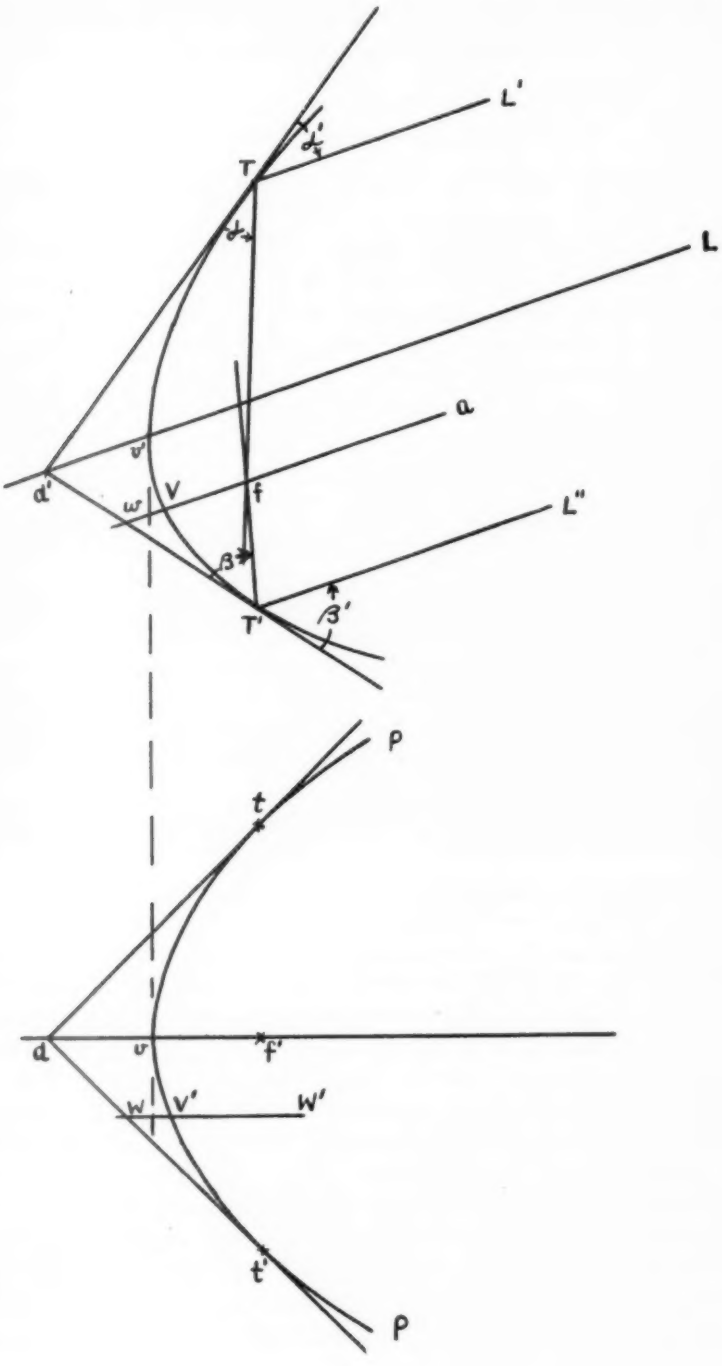
$$y = y_1 + y_2 \,;\, y_1 = mx + k,\, y_2 = \pm \sqrt{2p(x-h)}. \tag{2}$$

Obviously, $y_1 = mx+k$ is the equation of a straight line (represented by L in the figure), and $y_2^2 = 2p(x-h)$ is a parabola (represented by P in the figure), whose axis is on the x-axis. Let v be the vertex of P, and d be the intersection of the axis and directrix of P. Let t and t' be the extremities of the latus rectum of P. Therefore dt and dt' are tangents to P; so is the vertical line through v. By addition of ordinates, d, v, t, and t' determine the points d', v', T, T'. vv', $d'T$ and $d'T'$ are tangents to the general parabola at v', T, and T', respectively. Since L passes through v', and through the midpoint of the chord $T'T$ parallel to vv', L is parallel to the axis a of the general parabola. Through T and T' draw the lines L' and L'' parallel to L. Constructing the angles α, β equal to α', β', the focus f is determined, and so a is determined. The axis a intersects vv' in a point w. Construct the line WW' parallel to the x-axis, by subtraction of ordinates, so $Wv = wv'$. Then the intersection V' of WW' with P determines, by addition of ordinates, the vertex V of the general parabola.

Since the focus and vertex are now known, the construction of the general parabola follows by well known methods.

It may be indicated that in case the "α, β" construction does not clearly determine f, the construction of focal radii may be made at T and v', or at T' and v'.

The corresponding construction of the general hyperbola will be discussed in a subsequent note.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THE INDUSTRIAL GEOGRAPHY OF MASSILLON, OHIO, IN RETROSPECT

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The city of Massillon, located in northern Stark County, Ohio, dates its incorporation to 1826. The original nucleus of the present city developed around an intersection of routes. One of these routes lay roughly in a north-south direction, connecting the Great Lakes with the Ohio valley. The other route lay in an east-west direction, and was destined to become a transcontinental roadway.

Industry and transportation in the United States in 1826 were integrated into small units. The north-south route through Massillon carried a stream of trade from lakes to river by a short route across the watershed. The east-west route at first was far less significant in Massillon's economic life. The West was not yet developed. (Chicago was incorporated in 1837.) Massillon thus first became oriented mainly along the important north-south roadway, and maps of the early town show a definite elongation of the urban agglomeration in these directions.

The coming of the Ohio Canal in 1831 served to accentuate this north-south orientation. With the advent of a cheap outlet, wheat lands were developed in the vicinity of Massillon. Each year in early July long lines of wagons stood at wharf and warehouse in the town, waiting for canal boats to carry their wheat to Cleveland and thence to the East.

With the great westward movement came the east-west railway to Massillon. It subsequently reached Chicago in the early 1860's. Then followed the opening of the vast level western grasslands, ideal for wheat culture. Here land was cheap, needed no clearing, and could be held and worked in large units. These favorable conditions, and the accessibility of the Great Lakes to the new farmlands, soon slowed the pace of the wheat stream from the rolling lands of eastern Ohio. The wheat era in Massillon's development soon passed.

During the period of decline in wheat came a series of developments in Massillon's industry related to small pockets of coal located near the town. This coal was part of the great Northern Appalachian field. Even before the railway north and south doomed the canal, coal from the port of Massillon flowed

north, and a black stream had begun to replace the dwindling golden one. At this time appeared the first signs of an iron and steel industry, based on local coal and access to other materials and markets by railway. Stoves, harvesters, iron hardware, and steel goods constituted the local range of products in the 70's. Industry began to take over the field vacated by commerce in the economic life of the town.

The coming of the automobile found Massillon with considerable experience in iron-and-steel making, and no serious disadvantage in location with reference to Detroit. (Within 200

Looking west along the transcontinental highway—the present commercial heart.

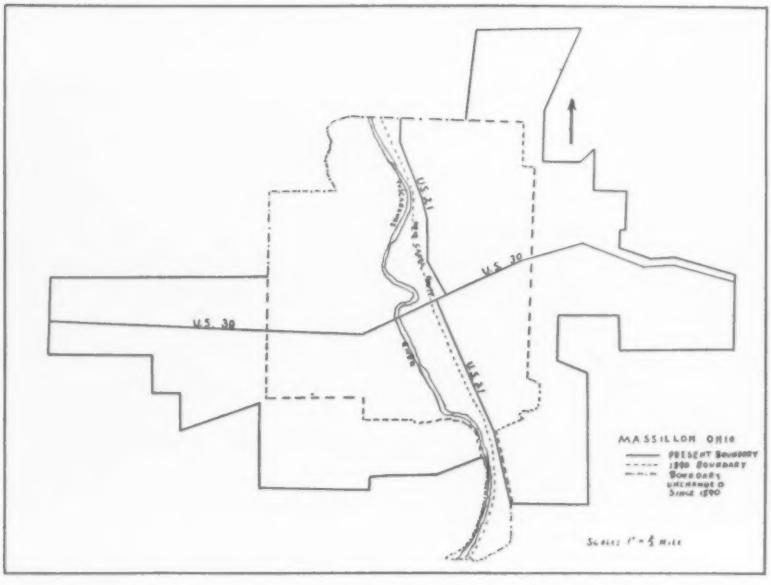
miles.) It was the automobile business, sheets and bars, which gave Massillon its greatest impetus. Its population doubled in the period 1910–1930.

The concentration of American industry into large units is a trend too well understood to merit detailed discussion here. Massillon's steel industry eventually was included among the widespread properties of the Republic Steel Corporation.

Until recently, three-fourths of the steel made in Massillon was sold to the automobile industry. But the Republic Corporation in 1938 completed a modern strip mill on the Cuyahoga River in Cleveland. This mill combines the advantages of modern methods of production with a position on the Great

Lakes, which makes the costs of raw material collection (excepting coal) and of marketing lower than these costs can be at Massillon.

A new stage in the community's ever-changing geography is appearing. Already two signs of it are in the landscape. First, a special stainless steel (which requires a high degree of skill in fabrication), developed in Massillon during the last twenty years, is finding wider markets as the trade becomes educated to its use. The stainless division of Republic Steel in Massillon is at present undergoing an expensive modernization and expan-



Massillon's present elongation in an east-west direction represents an interesting about face.

sion. Second, small local industries which use alloy steel as a raw material are developing. Among these are plants making automobile springs, roller bearings, and accessories.

Massillon's present elongation in an east-west direction represents an interesting about-face. This is, of course, due to the greater present significance of the transcontinental than the lakes-to-river highway and railroad. Maps of 1840 and 1939 reveal this striking change in the form of the community. Two once thriving commercial nuclei, located at the points where railways interesect each of the main highways, show decay,

and now represent largely only slum tenement districts. Decadence has, of course, affected least the old nucleus on the transcontinental highway.

It is interesting to note the line of warehouses which once fronted the canal, and now merely serve as reminders of the course followed by this waterway through Massillon. The portion of the canal within the city has been converted into a covered storm sewer. The commercial heart of Massillon now surrounds the intersection of the two main highways. Business

A decadent business section opposite the town's most important railway station.

related to the tourist trade—tourist homes, a china store, gasoline stations, a drive-in dairy store—spreads along the two main highways far out from the commercial heart of Massillon. In this adjustment to the tourist trade is further emphasized the superior importance of the transcontinental highway.

So moves the procession. Massillon serves only to illustrate the never-ending evolution of an industrial community.

Approximately twice as many boys as girls fail (in elementary school). . . . I believe that the boys' failures are at least partially due to the over-predominance of women in the schools. Women put a premium on conformity and docility—qualities in which girls excel.—*Professor Walter Anderson, Northwestern University.*

THE PROBLEM OF CONSERVATION IN TEACHER EDUCATION FROM THE STANDPOINT OF THE NATIONAL, FEDERAL, AND JUVENILE ORGANIZATIONS*

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INTRODUCTION

One of the important problems of conservation in teacher education is to find suitable authenic material from which programs in conservation can be evolved. Therefore, I will concentrate largely on this problem.

Normal school and college teachers are able to teach the principles of conservation from material found in the standard references such as, *Conservation of our Natural Resources* by Van Hise and Havemeyer, or *Our Natural Resources and Their Conservation* by Perkins and Whitaker. However, when you attempt to have prospective teachers prepare teaching units or assemble acceptable material for use in grades or high school, you will at once realize the paucity of good material and the abundance of trash, disguised as teaching material but really vicious propaganda.

There are many sources of conservation material, some of the more reliable ones being the Federal agencies, such as the National Park Service, United States Forest Service, Soil Conservation Service and Biological Survey. Some teachers fail to realize the value and importance of government bulletins, and a few are prejudiced against them. Many teachers fall prey to less reputable material that has been highly advertized or made more readily available. May I point out here, that while this latter type of material has a place and at times a worthy purpose, it is not the kind of information on which we should base our conservation teaching. Most government bulletins are and should continue to be, statements of fact, based upon research and not opinions of inspired or prejudiced editors or other laymen.

We have to realize too that many teachers are not qualified yet to prepare teaching units in conservation. This is illustrated by some of the recent chapters added judiciously at the end of Biology texts. Others do not have time to prepare original

* Presented to the Fourteenth Conference on the Education of Teachers of Science. Teachers College, Columbia University, New York City. April 29, 1939.

material, even though qualified, and have to rely upon prepared syllabi or text-book material. For these people, we would recommend the few available outlines, knowing that they may fall far short of satisfying local needs or specific problems.

Sources of Outlines, Syllabi and Guides

The Forest Service has prepared several guides of interest and have several others in the process of preparation. One that is available now, is called "Forest Conservation, a forest guide in the social studies." by W. P. Beard. 153 mimeographed pages published in 1937. An earlier one prepared for the C.C.C. advisers contains many good suggestions for teachers. It was called, "Forestry: outlines of instruction for educational advisers etc.," 128 pages published in 1935.

The Soil Conservation Service has prepared numerous units at all grade levels, but they are for the most part, outlines that have been prepared in cooperation with local workers for a specific school or region. Often they are used only by the Service staff members for giving a series of lectures or courses in an area. Nevertheless, some of these are available and should be consulted for suitable suggestions on soil erosion, and water conservation. Requests for this material should be sent to Miss Helen Strong located in Washington, or to the Regional Offices. The local one is located at Upper Darby, Penna. Teachers wishing to have their cooperation in preparing material should correspond with Dr. Strong. This office likewise prepared an outline for C.C.C. educational advisers, published in 1935.

The Extension Service has recently had Miss Ruth Lohman, a Payne Fellow, compile a series of specific suggestions for 4-H leaders on birds, mammals, fish, flowers, and other biological groups. This is most adaptable to schools located in or near the country where outdoor projects can be undertaken. The title of this valuable bulletin is "Teaching Conservation of Wildlife Through 4-H Clubs." It was published in 1938 and can be obtained from the Superintendent of Documents. An earlier one in 1936, Misc. Exten. Bull. 28 gives a selected list of references on the conservation of wildlife.

The Office of Education has attempted to enter the field and has to date published one bulletin and held one conference for teachers. The bulletin is called "Conservation in the Education Program" and can be obtained for 10¢ at the Government Printing Office. Although it was prepared to help teachers out-

line units, some will be disappointed in the brevity and generalizations. Even though prepared hastily, many suggestions and references will be found in it worthy of consideration. A short selected list of references is also available from this agency.

The suggestions for activities found in the Camp Fire Girl Birthday Honor for 1938 and the Boy Scout Conservation Merit Badge pamphlet may be of some help. The former can be found in various copies of the *Guardian*, the official magazine for Camp Fire Leaders. The latter can be obtained from local or national scout headquarters.

Although not dealing specifically with State agencies, I cannot help mentioning several worth-while government pamphlets having specific suggestions for conservation units. These come from Wisconsin, Virginia, and New York. "Teaching Conservation in Wisconsin Schools" is the title of a bulletin published in May 1937 by the State Department of Education. It was prepared largely by a committee of college people and contains pertinent suggestions for the conservation of soil, mineral resources, scenic and historic resources, forests and wild vegetation, and wildlife, with specific ideas for various grades.

From West Virginia we get a bulletin entitled, "Conservation of the Renewable and Non-renewable Resources of West Virginia," published by the Department of Conservation. Although not adopted as the state program it is full of useful material.

From New York we have the valuable series of Cornell leaflets published by the College of Agriculture, three of which pertain directly to conservation and many of the others related to it. The title of those dealing with this subject are "Conservation," "Are They Vermin?" and "Save the Soil." Although not definitely graded they are suitable for the grades, and some material can be used in high school and even college.

Conservation References

There are many teachers who will not be satisfied to adopt specific programs in toto or in part. To these teachers we offer our congratulations and much of our attention. It is a real pleasure to superintendents and principals nowadays to find a teacher content only to teach from material that she has been inspired to prepare or remodel. In these days of large classes and varied subjects, it is quite a problem to do this, and with

those who can't, we can sympathize, but we know that they will not enjoy their teaching nearly as much and the children will not get the keen pleasure that they might from such a potential subject.

Many references or supplementary bulletins have been prepared and can be obtained by teachers wishing to work out their own outlines. The following are a selected few from federal agencies.

The Biological Survey has a great deal of information on birds, mammals, pets, trapping, and the like, available in pamphlets, mimeographed sheets, and farmers bulletins. These can be secured from the Washington office or from the Government Printing Office at very low cost and in many cases free of charge. One of the outstanding ones, surpassing all others in popularity is "Fifty Common Birds of Farm and Orchard," having colored plates of the fifty species discussed. Other pertinent ones deal with plants and houses useful in attracting birds in different parts of the country. A complete list of those available will be sent upon request giving prices.

The United States Forest Service has catered more to teachers interests than most of the other older agencies. The titles of the following bulletins indicate the nature of their offerings: "The Forest; A Handbook for Teachers," "Material of Interest to Teachers," "Our Forests, What They Are and What They Mean to Us," "Here Are Forests, Their Relation to Human Progress in the Age of Power," "Taming Our Forests" and "What Forests Give." The last ones are the most recent ones and are far more attractive than the earlier ones, but may be not any more useful. They also publish many maps of forest areas with detailed descriptions and posters urging the conservation of forests. A list of their complete file of materials will be gladly sent to any teacher. A letter to W. P. Beard, requesting help on any curriculum problem related to forestry, will receive instant attention. He is especially anxious to cooperate with text-book writers in bringing the forestry text and pictures up to date.

The Soil Conservation Service is a new government agency, but in its short five or six years' existence it has published a tremendous amount of basic information on soil erosion and water conservation. Many of the bulletins are localized dealing with problems in the various regions. Others have been prepared in conjunction with other agencies. All of them are attrac-

tively illustrated. A complete bibliography on these subjects has been prepared by the Service and can be obtained as well as a shorter list of available bulletins. Many of these can be obtained from the regional offices free of charge. Colleges not already receiving them can often be placed on the mailing list to receive them as they are printed. A few of the more outstanding bulletins are: "Little Waters," "Erosion Control in the Northeast," "Ten Billion Little Dams," and "Topsoil, Its Preservation."

The National Park Service, being an agency founded on the principles and ideals of conservation, has numerous materials available for teachers' use. Their descriptive folders about each park are renowned for their pictures and delightful descriptions, and of course are easily obtained free of charge. In addition several important bulletins have been published dealing with the wildlife in the parks, numbered Fauna Series 1 and 2 and entitled "Fauna of the National Parks of United States." These are supplied at cost by the Government Printing Office. Two bulletins about the work of the park service are useful to teachers. They are "The National Parks and Emergency Conservation," and "Research and Education in the National Parks." Last year a series of mimeographed bulletins was prepared called "Celebrated Conservationists and Naturalists in our National Parks." They covered such men as Audubon, Say, Wilson, Bartrams, Micheaux, Rafinesque, and others, giving biographical material and pointing out possible associations with parks or areas later made into parks.

The Extension Service can supply a few bulletins in addition to the one mentioned previously by Miss Lohmann. These are prepared by various states and should be obtained from the separate states. I would recommend those from Massachusetts, Ohio, Michigan, Virginia, West Virginia, and Iowa. Although mainly prepared for 4-H Club use these have many projects outlined, suggesting studies on bird, mammal, flower, fish, insect, and tree.

Visual Materials

Most schools and teachers recognize the value of visual materials. A few have been prepared on conservation nationally and others pertain to local conditions. The most universally shown ones are "The Plough That Broke the Plain," and "The River," both exceptional stories that should be viewed by every

child and every adult. They can be borrowed for a showing in your school at practically no cost. These and many other materials such as film strips, lantern slides, and pictures can be obtained through the Division of Motion Pictures in the Department of Agriculture, for the transportation charges.

Inspection Trips

Inspection trips add zest to any activated program and can be arranged rather easily in most communities outside the larger cities. This can be done usually through a local representative of the federal agency located in your district. This would be the Regional Biologist of the Biological Survey or a Sanctuary Warden, a Project Manager or Regional Director of the Soil Conservation Service, A Forest Ranger from a local National Forest or the Regional Office, or a Guide in one of the State or National Parks. These people like to see visitors using the public facilities and are glad to help you arrange a short trip or a more lengthy tour.

Summary

1. Teachers having a limited amount of time and interest, and yet inclined to teach some conservation, can obtain a few specific outlined programs or units of work from several federal agencies and national youth groups. Additional ones can be secured from some states.

2. Teachers or administrators wishing to prepare original syllabi or units can obtain an enormous amount of material including valuable low-cost literature and visual aids from federal agencies.

3. Federal agencies equipped and interested in helping teachers in wildlife conservation work are: United State Biological Survey, United States Forest Service, United States Extension Service, National Park Service, United States Soil Conservation Service, and Office of Education. Youth agencies having a limited amount of material are Camp Fire Girls and Boy Scouts of America.

4. No teacher should feel that she cannot participate in a conservation education program because of insufficient sources of worth-while materials. Attention is needed acutely on the problem of assimilation of this voluminous material into the school program. It should be done by teachers in service with a fairly scientific background in conservation.

PROGRESS IN EXACT SCIENCE

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Prior to 600 B.C. man had made but little progress in interpreting his environment. For him the center of the universe was marked by a stationary earth. Around the earth were one or more spheres which carried the moon, the planets, and the fixed stars. The motion of the sun was accounted for by saying that it was heated each morning at the forge of Vulcan who then took it in his tongs and threw it across the sky. Each evening it was carried back in a row-boat. The Milky Way was the milk maid's path. Legends similar to these were without number. The universe centered around mankind. Whims, caprice and astrology dominated. Nature was thought to be chaotic. Natural law was unknown.

With the advent of geometry as a science, measurement, experiment, and proof assumed a role of increasing importance. The earth was found to be spherical and out in space. Day and night were accounted for by assuming the rotation of the earth on its axis. The circumference of the earth was measured. The phases of the moon and the phenomena of eclipses were explained. From the data on similar triangles, obtained during eclipses, the distance to the moon was found to be 59 times the radius of the earth or about 233,000 miles. The measurements of Aristarchus gave for the sun a distance of twenty times and a volume of 8000 times that of the moon. These data indicated that the volume of the sun was at least a hundred times that of the earth and that its distance was nearly 5 million miles. In the course of time the comparatively greater volume of the sun together with its enormous distance, naturally led to the overthrow of the "row-boat ideas" and to the establishment of the helio-centric hypothesis which gave a rational explanation for the seasons and for the length of the year. One of the permanent contributions of this intellectual awakening which began with Thales 600 B.C. and largely closed with the death of Archimedes 212 B.C., was the Euclidean geometry and its applications in the arts, in architecture and in science, especially in the interpretation of the solar system.

Near the close of the so-called "dark ages" the helio-centric hypothesis, which had been dormant for nearly eighteen centuries, was revived by Leonardo di Vinci (1452–1519) and defi-

nitely championed by Copernicus (1453–1543). About 1609 this hypothesis was further confirmed by the discoveries of Kepler who stated the laws of planetary motion. These laws did much to establish the experimental method, "the corner stone of modern science," as the sane and rational method of interpreting nature.

About 1610 A.D. Galileo disproved the erroneous theory of Aristotle that the velocity of a falling body is proportional to its weight, and through experiment established the now accepted laws. He dealt with projectiles, with velocity and acceleration, distinguished between weight and mass, and paved the way for the study of modern mechanics. His construction of the telescope was a contribution of universal interest. Visible through the telescope were the craters of the moon, the satellites of Jupiter, the phases of Venus and many of the dim stars of the Milky Way. In fact, the telescope revealed an immensely larger universe. With this modest beginning the number of stars that could be observed was increased from about 5000 in 1610 to easily 40 billion in 1938.

Starting with the notions of Kepler, Galileo, and Huygens, regarding the physical world, Newton combined these unit investigations, laws and concepts, into an ordered whole and stated the so-called Newton's laws of motion together with the law (or hypothesis) of universal gravitation. These laws have been found to be very far reaching in the interpretation of the solar system, in explaining the orbits of the planets and the comets, and in establishing the idea of oneness and natural law in the known universe. The degree of exactness of Newton's law of universal gravitation for bodies having a relatively slow motion is well illustrated in the work of Adams and Leverrier, who in 1846 determined mathematically the position of the unknown planet later called Neptune, and in the calculations of Lowell which led to the discovery of Pluto in 1930.

The first attempt to measure the velocity of light was made by Galileo by flashing signals with lanterns. He learned that the speed of light must be very great. In 1675 A.D., by observation on an occulation of one of Jupiter's moons, Roemer found that the velocity of light was approximately 186,000 miles per second. In 1727 the velocity of the ether waves was confirmed by Bradley through his measurement of the aberation of light. These experiments indicated that the velocity of ether waves, although very great, was finite. Hence the distance to a

star could be expressed in terms of the distance light travels in a year, a distance called a "light year." By 1838 A.D. astronomical instruments had been brought to such a precision that it was possible to measure an angle expressed in fractions of a second of arc. In this year the first accurate measurement of the distance to a star was obtained, namely 4.3 light years. That was one hundred years ago. Today we measure the distance to the stars, the clusters, and even the most remote visible nebulae. In fact the telescope aided by Euclidean geometry has explored the surrounding space quite extensively up to 50 million light years and to some extent up to 500 million light years. Not only did mathematics function in establishing the concept of natural law, but it has aided greatly in the interpretation of the known universe and in establishing a basis for further scientific investigation.

In 1859 A.D. Leverrier noted that the major axis of Mercury's orbit was rotating through an angle of about 43″ each century. Near the opening of the twentieth century we find the Fizeau experiment on the velocity of light, the Michelson-Morley experiment on the ether drag, the Fitzgerald-Lorentz contraction theory, and Rutherford's discovery of the great amount of open space within the atom, and therefore inside all material objects. From certain experiments Kaufmann found that the mass of an electron is changed when given a sufficiently high velocity; that is the mass of an electron varies with its velocity or with the energy carried by it. This experiment caused the rejection of the time honored principles of (a) the conservation of energy and (b) the conservation of mass and gave us instead the conservation of mass-energy. The latter principle states that the sum total of the mass and the energy is constant. A little later Rutherford and Soddy demonstrated that the mass of a radium atom did actually change as a result of emanations, in fact, radium changed to another chemical element, namely lead. It now seems that the conservation factor which plays a part between mass and energy is the square of the velocity of light.

Other very troublesome discoveries were (a) the quantum theory of matter stated about 1900 A.D. which postulated that energy occurs in "bundles" of definite size and (b) the accounting for the prolonged life of the sun by assuming the transformation of matter into energy. This transformation may be found in the atomic weight of hydrogen which is 1.008 and the

atomic weight of helium which consists of four particles each of whose masses is practically equal to the sum of the masses in the hydrogen atom but whose total atomic weight is only 4.026. This difference in mass is present probably as the energy binding the helium atom. In 1905 the quantum theory was extended to cover the energy relation within the atom and thereby paved the way for the atomic theory of Niels Bohr.

By 1900 A.D. the many slight variations which began to appear between theory and fact had resulted in a flood of new experiments dealing with high velocities and time. The determination of the velocity of α and β particles; that electricity and magnetism are related phenomena of radiation; that light is composed of two disturbances at right angles to each other, one electric, the other magnetic, etc; raised a host of new questions in mechanics. These questions in turn called for mathematical expressions which would enable investigators to deal with exceedingly abstract theories, to predict results such as the exact time of an eclipse, to determine the cause of the perturbations of planets, to explain the change in the position of the orbit of Mercury, to find better methods in radio broadcasting, and to make more delicate and refined astronomical measurements.

Faraday and Henry made observations on electrostatic and magnetic fields of force. These concepts of a field of force led to Clerk Maxwell's (1830–1879) famous mathematical treatment of an electro-magnetic theory in which he predicted the existence of electro-magnetic waves which travelled with the speed of light. This treatment, completed in 1864 reduced the whole theory of electro-magnetism to a small number of equations. Later such phenomena as X-rays, gamma rays, ultra-violet rays, visible light, heat radiation and radio-broadcasting were studied by the aid of similar equations. Still later it was found that space waves, one and all, are the same kind of disturbances but differ in wave lengths. Through his mathematical treatment, Maxwell erected a magnificent structure in which he showed that (1) electric waves could travel through space with the speed of light; (2) an electric wave was associated with a magnetic wave and conversely; (3) electric waves are transverse.

This structure was a purely theoretical advance suggested by the application of strict mathematical reasoning even before it was known that electric waves could be produced. In 1887 A.D., Hertz devised apparatus by means of which he was able

to demonstrate the existence of waves produced by an oscillating electric circuit. These waves were detected across the space of his laboratory. It was a crude experiment made to test Maxwell's mathematical equations and was the first known instance of wireless transmission. In 1899 similar experiments were made by Marconi who succeeded in sending and receiving messages across the English channel, and in 1901 across the Atlantic Ocean. It was he who gave us the modern wireless transmission, used for signaling ships at sea, aircraft in the air, which has added so much to the safety in travel. Through the radio broadcasting of news, lectures and concerts, these investigations may yet change the whole trend of social, educational, and political progress. Thus Faraday's experiment of rubbing amber and Maxwell's theory, in which radio was born as a mathematical equation, have now been expanded into a vast science, with ramifications in almost every branch of human endeavor. This development emphasizes the fact that in every exact science there arrives a stage in its history where observation and speculation must give way to a precise manipulation, of a purely mathematical nature. This makes mathematics a necessity since it furnishes the only available means whereby we can be assured of the proper degree of exactness and precision.

Prior to 1890 A.D. physicists and astronomers based their theories, quite largely, on the assumption that space is Euclidean; that is, space waves travel in straight lines regardless of the matter in the given region. This was a tacit assumption of the so-called parallel postulate, although it had been questioned from about the time of Euclid. So many were the attempts made to prove this postulate without success that in the latter part of the 18th century it began to dawn on mathematicians that it could not be proved but that it might be a special case of a more general relation.

About 1826 A.D. Lobachevsky, a Russian, and Bolyai, a Hungarian, assumed that the one parallel axiom of Euclid could be replaced by the assumption that more than one distinct line can be drawn through a point P each of which, in its limiting position, will be parallel to a given line l. This is equivalent to assuming that space is non-Euclidean, that is, space rays do not necessarily travel in straight lines. To illustrate what we mean by this statement, let a line m revolve about P and intersect l at Q. As Q moves to the right on l the line m revolves about P and seems to approach a limiting

position in which m does not meet l. It is therefore parallel to l. Similarly if a line n through P meets l in R and R moves along l to the left, PR will assume a limiting position in which n does not meet l. Then n is also parallel to l. Euclid assumed that these lines m and n in their limiting positions are one and the same line, hence only one line can be drawn through P parallel to l. Since it was assumed that space waves were not acted on by gravitation their lines of motion must be straight lines; hence each space wave lies wholly in a Euclidean plane.

Lobachevsky assumed that m and n are distinct lines intersecting at an angle. Therefore all of the lines through P which lie in one angle between m and n, since they do not meet l, might be said to be parallel to l. Since an infinite number of lines can be drawn through P that do not meet l, there are an infinite number of lines through P that are described as being parallel to l. This is equivalent to assuming that a plane in space may be shaped somewhat like a hyperboloid and that on such a surface parallel lines diverge. Hence such a surface, which is not a Euclidean plane except in the limiting case, may have value in explaining an expanding universe in which the pressure of the space waves is greater than the attractive force of gravitation. It was Lobachevsky, the great emancipator, the independent thinker, who recognized in Euclid a special case, and created a new geometry thus opening a new world to be explored and interpreted by physical science.

About 1854 A.D. Riemann rejected Euclid's parallel axiom for space and made the assumption that a straight line is not infinite in length, and that co-planar lines perpendicular to a given line intersect. This is equivalent to assuming that a plane in space is curved somewhat like the surface of a sphere or ellipsoid. On such a surface there are no parallel lines in a Euclidean sense; hence, lines perpendicular to a given line would converge. According to the theory of relativity this would be true in a world containing matter. In the field of engineering any one of these geometries is true but the Euclidean geometry which is a special or limiting case is much simpler in calculation.

These investigations raised questions as to what we are to assume as to the nature of space in astro-physics. Given a line and a point outside it, it is possible to draw through the point precisely one parallel, no parallels, or more than one parallel depending on the assumptions made in regard to the nature of space.

In a Lobachevski world, heat, light and other space rays would become farther and farther apart.

In a Riemann world, space rays would be curved continually by the attractive force of gravitation. In this case we would live in a universe finite but unbounded. Since in the non-Euclidean geometries all of Euclid's common notions (later called axioms) except the one on parallel lines may be retained, only the theorems depending on this common notion will be changed. Before me are the statements in English of six theorems which are true in both Euclid and in the geometry of Lobachevsky. Four of them are also true in the Riemann geometry.

Measurement does not enable one to decide which one of these geometries actually applies in the physical world. In recent years non-Euclidean geometry has been found useful in explaining the structure of the universe. In the discussion of the uniform-field theory, Einstein makes use of a non-Euclidean geometry slightly different from either of the ones described above. The introduction of non-Euclidean geometry was a momentous event in the history of thought. It brought about the first positive advance in the subject of gravitation since the time of Newton and suggested that any satisfactory explanation of gravitation would probably transcend the limitations of Euclidean three dimensional geometry. In this way non-Euclidean geometry afforded a new point for theories describing the physical world. Like the discovery of the helio-centric hypothesis, the law of universal gravitation, and the theory of evolution, the invention of non-Euclidean geometry radically changed many ideas regarding the physical world, aided in paving the way for the theory of relativity, and raised certain questions regarding the nature of mathematics, namely, "What is mathematics?"

Near the beginning of the present century the known universe was thought of as consisting of matter occupying space. Matter and space waves were supposed to obey the laws of Euclidean geometry. Besides these assumptions, were the notions of absolute space, time, length, Newton's laws of motion, the concept of an ether and the force of gravitation. According to Galileo and Newton, space and time were absolute entities, that is, the concept of absolute space existed aside from absolute time. Hence one could think of space and force without reference to time, provided one thought in the geometry of Euclid.

On these concepts was built the science of Newtonian mechanics. Hence, the resulting formulas were sufficient for static conditions or motions of a slow nature. Later it was found that these conditions did not conform to the phenomena in electrodynamics where the velocity is many thousands of miles per second, such as is found in α and β particles. More recently it became evident that in very high velocities Newtonian mechanics was only a first approximation and not an absolute condition. The tendency toward exactness was found to be progressively less as the velocities concerned approached that of light.

Just as the discoveries of Kepler, Galileo, and Huygens paved the way for Newton, so the experiments of the latter part of the 19th century and the early part of the 20th century paved the way for a somewhat revolutionary theory. Non-Euclidean geometries, which were later to form the mathematical framework of Einstein's theories were being developed. Scientists were speculating on certain fundamental postulates which would stand the test of experiments and would include all physical phenomena. From these postulates the aim was to work out a mathematical theory which would be comprehensive enough to include an explanation of gravitation, electro-magnetic fields, and such laws as underlie the electron, the proton, and the quantum theory. To some extent this theory has been developed by Einstein who conceived its importance and fundamental nature. Since laboratories can not readily produce the great ranges in temperature required in these investigations, their verifications are largely to be found in the field of astrophysics where nature provides the required conditions of mass, temperature, and velocity.

Einstein's postulates may be stated:

I. If an experiment is performed in a closed car which is moving with uniform velocity and without vibration it is impossible for an observer within the car to determine whether or not the car is in motion.

II. The velocity of light is the same for all observers whether they are moving or not, and is independent of any motion in the source of the light.

From these postulates there are several important deductions, some of which are truly revolutionary.

1. There is no precedent to establish absolute motion. All motion is relative.

2. The laws of nature are universal. Their form is invariant and not dependent on the axes of reference used.
3. The size of material objects as measured by an observer, depends on the relative motion of the object and the observer.
4. Two observers moving with respect to each other will each think that the other has shrunk in the direction of motion. If these observers are moving with respect to each other, neither one knows which one is moving or what their true motions are.
5. The apparent increase in the mass of moving charges is a general property of matter.
6. The energy contained in mass at rest (at ordinary temperatures) is equal to the mass multiplied by the square of the velocity of light.
7. The Newtonian idea of absolute space and absolute time is replaced by local space and local time.
8. There is no such thing as the determination of absolute simultaneity at two separate points.

In his first theory Einstein merely used the three-dimensional Euclidean system enriched by the introduction of the idea of local time, usually called a fourth dimension. In this system he discards both absolute time and absolute space and makes them, in every case, relative to a moving system; that is, he rejects the idea of absolute or universal time and substituted local times attached to moving bodies and varying according to velocity. In this way the phenomena in electro-dynamics and mechanics, heretofore irreducible by the older formulae, and there were many of them, is now satisfactorily explained. Besides we find principles which unify such varied concepts as mass, momentum, energy, electricity and magnetism.

In the case of his general theory of 1916 he found it necessary to resort to the geometry of Riemann. In general, Einstein assumes that space is Euclidean and that light travels in straight lines where it is sufficiently remote from matter, but the presence of matter renders it slightly non-Euclidean. Hence, a ray of light or other space wave will be bent, due to the presence of matter. In the course of time such a ray might return on itself. Such a ray always remains within a finite but unbounded space. The more matter there is to attract the ray, the more it will depart from a straight line and the smaller will be the given space of enclosure.

The theory of 1905 made noteworthy contributions, namely:

1. The quantum theory was extended to cover the energy relation within the atom wherein the explanation of specific heats of bodies at low temperatures as given by measurement and prediction did not agree. In this way relativity paved the way for the atomic theory of Niels Bohr.
2. The quantum relation was applied to the photo-electric effect. This gave further confirmatory evidence of the quantum theory.
3. Relativity related electricity and magnetism. A change in mass occurs with a change in the velocity of a moving charged particle. Hence, mass must be electro-magnetic in its nature.

The Einstein theory of gravitation does away with the traditional ether, and explains gravitation as an acceleration of space in the presence of matter. In fact gravity is explained in terms of mechanical motion and the effect of gravitation in terms of accelerated motion.

Although no direct measurement of the universe can be expected, the present day telescope reaches out to a distance of 500 million light years and renders visible a 100 million island galaxies, each somewhat comparable in size to the Milky Way system of which our solar system is a part. In these systems velocities are sometimes very high. Some parts of the Orion nebula have velocities exceeding two thousand miles per second. One star in the bowl of the Big Dipper has a velocity exceeding seven thousand miles per second. The largest velocity recorded, as measured by the red-shift, represents a speed of 25,000 miles per second, or one-eighth of the velocity of light.

To account for the phenomena exhibited by these rapidly moving bodies, so abundant in nature, Einstein put forth his famous theory of relativity developed as a mathematical formula, which was generalized to some extent in 1916. This general theory which includes accelerated motion as well as centrifugal force, was revolutionary in man's thinking. It was found to account for a number of features better than did the Newtonian mechanics of stationary objects. Among the conditions that relativity predicted would be true are:

1. The displacement of the perihelion of Mercury's orbit which amounts to 42″ of arc in 100 years.
2. The deflection of rays of light in passing the sun. This deflection, which was about 1.74″ of arc, indicated that

motion was equivalent to mass and could be acted on by gravitation.

3. There is a shift in the spectral lines of light coming from a huge mass. This is due to the slowing down of the electron when in an intense gravitational field.

Light coming from the sun's surface will use up some of its energy in escaping from the sun's gravitational attraction. Hence, the atomic vibration of light waves coming from the sun are executed more slowly. This causes a shift of the spectral lines toward the red end as compared with light from a terrestial atom which does not suffer this loss. The effect on the light waves would be the same as if the body were receding. This shift of the spectral lines seems to be fairly well verified in the case of the companion of Sirius, a "white dwarf," whose density is some 60,000 times that of water. According to the theory the shift should be 20 units. According to observation it is 19 of the same units. This shift of the spectral lines is regarded as a remarkable confirmation of the theory of relativity. The extreme density of this matter is due to the fact that many of the electrons have been torn from the atoms under the action of great pressure and high temperature, thus allowing the protons to come closer together.

As an illustration it is said that if the electrons could be torn from the atoms of the human body, the protons could be condensed into a particle of matter barely visible with the microscope. This means that so-called solid matter is composed of space largely. Relatively speaking it may be said that the open space in an atom is comparable to the open space in the solar system.

Another interesting example of Einstein's work is found in the photo-electric equation. In 1887 Hertz discovered that ultraviolet light had an effect on an electrical discharge. In 1905, at the age of twenty-six, Einstein gave us his theory of the photo-electric effect in the form of an equation which related the electric behavior to the wave length of the light used in producing this effect. This was verified by Millikan in 1916. We now have all manner of photo-electric devices in which light changes are converted into electric changes. These devices control traffic lights, level elevators, match delicate colors with great speed and accuracy, give us talking motion-pictures, the television, besides a whole retinue of robots.

In the theory of relativity the word space takes on a new

meaning. It has length, breadth, height and time. In fact, relativity is based on a complete union of space and time.

In the theory of relativity there has been no contradiction of the so-called basic laws (such as the law of falling bodies) but rather a more complete appreciation of the restricted nature of theories previously considered general. With the coming of the 20th century mechanics with its exactness of measurements and high velocities, a new situation arose which could not be interpreted by the older laws based on statics. Not unlike the situation which confronted Archimedes and Newton, Einstein found a great field, ready for interpretation and extension. His great mathematical genius and his genius for things scientific, enabled him to interpret conditions and eventually change the whole mode of scientific thought.

In his first work he was able to build up equations to test what is known as the "Brownian movement in gases" which had puzzled physicists for more than fifty years. These never-ceasing zigzag movements of particles larger than molecules, but so small that they can just be seen under a high powered microscope, were such as to suggest life. He was able to show through calculations that these movements were due to unequal bombardment by molecules from opposite sides. This explanation further substantiated the kinetic theory of gases. His contributions, in the field of electronic, atomic and molecular physics as well as in the science which underlies the photo-electric cell, have been very great.

This cursory glance at the development of science will indicate the progressive aspect and show a tendency to reduce the phenomena of nature to that of law and order, which in the successive ages gives to man a higher and a still higher control of his environment.

Although the wealth of deductions through these unified principles is astonishingly large, possibly the greatest gift of these investigators is their philosophy of life. Newton's contribution to rational thinking has not even yet been fully appreciated. Einstein has more than any one else of this generation added a deeper significance to our lives, and has opened to us something more of the great plan of the universe. His theories have the highest degree of aesthetic merit and, whether we grasp his theories or not, every lover of the beautiful must at least want Einstein's theory to be true. His ideas on relativity have already had a profound effect on the philosophy of the

problems of space, time, causality, free will, and the nature of physical concepts such as force, mass, and energy. It was Einstein who saw the need for a new way of looking at things, and in working out his method he has modified not only the mode of scientific thought, but the mode of thinking of the entire world as well.

MORE ECONOMIES IN THE CHEMISTRY LABORATORY

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In a previous article,* suggestions were made as to economies which might be practiced in schools where the funds available for the purchase of supplies for teaching chemistry were limited. The following items may be considered as supplementary to that list.

1. The practice of janitors in turning off the water in the laboratory at night and turning it on again in the morning is the cause of much breakage of glassware. For when Johnny holds a flask or beaker under the faucet and turns on the water, there comes out a blast of compressed air which blows the glass out of his hand. It might be well for the teacher to instruct some student just before the laboratory exercise begins to turn on the water at every faucet and after a moment shut it off; this would allow the imprisoned air to escape so that breakage would not follow.

2. Much of the breakage of glassware in the laboratory is due to the inexperience or ignorance of the student, rather than to carelessness. No class should ever go to the laboratory, particularly at the beginning of the year, without careful instruction as to proper procedures. Much breakage may thus be avoided. Observe the following:

3. Glassware which is to be heated MUST be dry on the outside, and on the inside too if it is to contain a solid. If the contents are liquid, the glassware need not first be dried inside, unless the presence of a small amount of water would injure the preparation.

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* Stone, Charles H. "Economy in the Chemical Laboratory," SCHOOL SCIENCE AND MATHEMATICS. 31, pp. 34–37, January, 1935.

4. Graduates, being tall and with small bases, are easily tipped over. As a consequence, the top is often broken off. This may be prevented by winding several thicknesses of narrow cloth around the top of the graduate, below the lip, and tying the cloth securely on. Adhesive tape is better. The layer of this protective material should be thick enough to provide against the top of the graduate striking on the desk when the graduate falls over. Rubber rings, which are specially made for this purpose, may be purchased from dealers. It is a pity that the manufacturers of graduates do not make them with hexagonal bases so that they cannot roll off the desk onto the floor with consequent breakage.

5. Experiments in which the generator or other pieces of ware must be destroyed may better be done as a desk demonstration rather than in the laboratory. The destructive distillation of wood and soft coal, the melting of sulphur, and the common experiment of heating together iron dust with sulphur are cases in point. If the last named experiment is done by thirty individuals in the laboratory, two and one-half dozen test tubes are destroyed; while if done as a desk experiment, only one tube is sacrificed. And so on with other similar experiments.

6. At the end of every experiment in which glass tubing is inserted into rubber stoppers or tubing, the two should be separated. If left in the attached condition, the glass and rubber soon so closely adhere as to be very difficult to separate. In such a case, a little water allowed to run down between the glass and the rubber (pull the rubber away from the glass) will often separate the two enough so that they can easily be taken apart.

7. Rubber stoppers which have become hard can be softened by soaking them in a hot solution of caustic soda.

8. Students should be instructed NEVER to attempt to whittle a rubber stopper to fit a flask or test tube. Get a smaller stopper or a flask with a larger neck.

9. If expensive chemicals are directed to be used in an experiment, silver nitrate for example, let the experiment be done at the teacher's desk rather than in the laboratory.

10. Certain chemicals can easily be made in the laboratory; lead nitrate from lead oxide, barium chloride from the carbonate, mercurous nitrate from mercury, etc. This is an interesting experiment to turn over to some bright member of the class as an extra.

11. Thistle tubes should never be held by the bell when in-

serting them into rubber stoppers. Hold by the stem. Wet the glass and also the hole in the stopper and the tube will go in much easier.

12. Iron crucibles should be heated with a moving flame, not too hot. If the flame is very hot and stays in one position, a hole may be burned in the crucible. Crucibles should be slightly inclined when resting on the triangle so that the flame does not come directly on the bottom.

13. For generating gases a bottle may generally be used in place of a flask, unless the generator is to be heated. In case of an explosion, such as that of hydrogen, the flask will be blown to bits, but with the bottle all that happens is that the stopper is blown out.

14. Florence flasks are pretty to look at but they have small bases and are hard to clean. Erlenmeyers have the advantage in both ways.

15. If an evaporating dish on the ring stand is very hot do not take it off with cold tongs; heat the tongs first. This avoids breakage.

16. Be sure when putting a funnel into the ring of a stand that the ring is not hot from some previous part of the experiment. The hot ring may crack the upper part of the funnel all the way around.

17. Hot dishes such as flasks and evaporating dishes are not to be placed on the top of the desk but on an asbestos or other protective base.

18. It is quite unnecessary to buy gas-receiving bottles. Students may bring in half a dozen bottles or jars apiece; the size and shape do not particularly matter.

19. Cover glasses need be only about two inches square. Waste glass from the hardware dealer may often be had for the asking. Set some student to cutting it up into small squares.

20. Students should be instructed that, when pouring a solid from a bottle, the container is not to be tipped up and up until half its contents come out all over the place; roll the bottle back and forth and the material will come out a little at a time. If the substance in the bottle is badly caked, call the instructor.

21. Do not drop hard materials such as zinc and marble into a flask; the bottom of the flask may be cracked. Slide the substance into the flask which is held in a horizontal position.

22. When using clamp to hold glassware, do not screw it up too tight.

23. Certain apparatus which is used only occasionally, such as blow-pipes and deflagrating spoons, may be kept at the side table and returned there when the students has finished the experiment. It is quite unnecessary to provide each student with articles which are rarely used.

24. Residues from experiments are often dumped into the sinks. Much of this material may be recovered for later use. Manganese dioxide and potassium chloride from oxygen preparation, zinc sulphate from the preparation of hydrogen, etc. are examples of recoveries.

25. It is not uncommon to find in the closets under the desks that pupils have put away their glassware first and finally landed an iron ring stand on top of it all. The result is often breakage. A little common sense should direct a different procedure.

The above observations may prove of value to certain teachers. All of the above have been proved in the writer's own classes.

UNDEFINED EXPRESSIONS INVOLVING FRACTIONAL EXPONENTS

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Most textbooks in algebra essentially give the definition:

$$a^{m/n} = \sqrt[n]{a^m} = (\sqrt[n]{a})^m.$$

However many fail to point out an important restriction on this definition: if n is an even integer, a must be positive. For example, although it is true that

$$+\sqrt{4^2} = +\sqrt{16} = +4$$

is the same as $(+\sqrt{4})^2 = (+2)^2 = 4$, it is by no means true that

$$+\sqrt{(-4)^2} = +\sqrt{16} = +4$$

is identical with

$$(+\sqrt{-4})^2 = (+2i)^2 = 4i^2 = -4.$$

Similar ambiguity arises if one considers $(-32)^{2/10}$. Its value, if we accept the definition at the first of this note, depends upon whether involution or evolution is performed first. The difficulty is not avoided by changing to the form $(-32)^{1/5}$ since the value of $(-32)^{3/10}$ is still unsettled.

Since when n is even and a negative the radical expressions $\sqrt[n]{a^m}$ and $(\sqrt[n]{a})^m$ are not equivalent and since there is no reason for a preference, it would seem better to leave $a^{m/n}$ undefined for n even and a negative. Unfortunately this exception is either omitted or at least not emphasized in many texts.

THE PLIGHT OF HIGH SCHOOL PHYSICS

I. Water-Tight Compartments

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I have before me, as I write, two curiosities. They are textbooks in science which were used in the high schools and academies in this country during the past century. The older of the two, Grund's *Natural Philosophy,* was published in Boston in 1832, over a hundred years ago. Its chapters, 10 in number, are titled:

Of the General Properties of Matter
Of the Phenomena of Cohesion, Attraction and Affinity
The Laws of Motion
Laws of Motion of Fluids
Mechanical Properties of the Atmosphere
Of Heat
Of Light
Of Electricity
Of Galvanism
Of Magnetism

The other book, Johnston's *Manual of Natural Philosophy,* published in Philadelphia in 1859 has seven chapters:

Mechanics
Hydrostatics
Pneumatics
Acoustics
Optics
Magnetism
Electricity

Putting away the past, we turn to two modern physics texts. They are both much larger, better appearing, and more attractively illustrated than their 19th century precursors. Their individual chapters tend to be smaller in scope but more discursive in treatment. They are grouped together under larger headings—headings which are often about the same as the individual chapter titles in the earlier books. One of these modern books (Clark, Gorton and Sears, *Physics of Today,* Houghton Mifflin Co., Boston, 1938) has ten such divisions, or *units* as they are called. They are:

Mechanics
Forces
Motion
Gravitation
Work, Energy and Power
Machinery
Heat
Sound
Light
Electricity and Magnetism

The second text (Black and Davis, *Elementary Practical Physics*. Macmillan, New York, 1938) has six large divisions as follows:

Mechanics
Heat
Magnetism and Electricity
Sound
Light
Modern Physics

Now, much might be made of these four lists. If we discount the efforts of those intrepid writers who dared to break up the traditional Mechanics material into such smaller units as "The Laws of Motion" of "Work, Energy and Power," we can use the lists to show the permanence of the sequence of topics in the physics course. Textbooks writers, at least, have generally been content with this immutability and have felt their responsibility discharged when they dovetailed the latest bits of scientific discovery into their proper niches in the old schema. But more important than the sequence, is the diuturnal survival of the divisions themselves—snug little water-tight compartments—Mechanics, Heat, Sound, Light, Electricity and Magnetism. Oh yes, we can experiment with the order and placement of these divisions. Even Johnston, as long ago as 1859 did not hesitate to place the topic of *Heat* in his textbook in *Chemistry*. But note that it is the compartment *Heat* that is taken over, *as a whole*. Now I can easily see how certain portions of traditional *Heat* might be used profitably in chemistry, e.g., in connection with fuels. But neither Johnston, nor modern text-book writers have dared so much, at least not the writers of texts in chemistry and physics. *Heat* was taken over as a unit—and taught as such. The inviolability of the classical divisions was preserved then—and is preserved today!

Now compartmentalization is bad. Speaking of the educational system as a whole, Bode has said: "Our educational practice of compartmentalization not only keeps basic problems out of sight, but adds to the difficulty of locating them,"[1] and again: "The compartmentalization . . . becomes a means for concealing from the student the things that he is most in need of knowing, if he is to lead an intelligent life."[2]

In the field of physics, compartmentalization has effectively concealed from all save the most discerning, the fundamental unity of the subject. It has made teaching pedestrian and unexciting, and learning difficult and devoid of pleasure. It has resulted in the separation of ideas that may well belong together. Thus, because the water turbine has always been taught in connection with Hydraulics, one of the classical divisions of Mechanics, and steam turbines in connection with Heat, we still continue conscientiously to separate them. In one modern text they are discussed on pages 83 and 309, respectively, a separation of 226 pages. And yet there are important similarities of construction and use between the two turbines. Both are prime movers of great importance in electrical power production. Or again, in this same text, we find the mechanical equivalent of heat discussed on page 301, work and power on page 53, and energy on page 224. The transmission of mechanical power is similarly carefully segregated by some 430 pages from the transmission of electrical power. Perhaps worst of all we find, in virtually all texts, that the discussion of efficiency and energy, two concepts that should be used with great frequency in any physics course, is limited almost completely to the pages in the Mechanics section where they first occur. Now it may be that not all these various groups of ideas would benefit by being brought together. Your decision in this matter will depend in large part, it seems to me, upon what you conceive the function of high school physics to be—whether it is a preparation for more physics, for the education of the science specialist, or whether physics is a subject to be used for the best education, the general education, of young people. If you favor the former, your decision may be—note that I say *may be*—to continue the boundaries of the sacred preserve. If the latter, you must—note

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[1] Kilpatrick, William H. Ed., *The Educational Frontier*. Ch. I, Bode, Boyd H., *The Confusion in Present-Day Education*, p. 6.

[2] Bode, Boyd H. loc. cit. p. 15.

the *must*—try to effect a more unified, integrated organization of ideas in the subject. We will assume that you decide that you should bring together those ideas from the field of physics that can be functionally related, without regard to the divisions from which they come. But beware! The strength of the compartmentalization idea is strong. So strong that even with persons who honestly think that they are effecting great changes, changes for the better, the old divisions still appear. Thus, when the teachers in the science department of the Exeter Academy report on their experimental physical science course (SCHOOL SCIENCE AND MATHEMATICS, Feb. 1939 p. 172–7) their list of topics for the first year course numbers 27 in all. Let us examine this list. We note the following: (Numbers are as in the published report)

1. Archimedes' Principle
2. Air Pressure: Barometer; Machines Depending upon Air
3. Expansion
4. Heat; Calories, Temperature, etc.
5. Transfer of Heat
6. Molecular Structure. Cohesion; Adhesion; Kinetic Theory
7. Vapor Pressure. Humidity, etc. Background to Begin Chemistry.
(Topics 8–20 are chemistry topics such as will be found as the titles to the chapters in most chemistry tests, although varying somewhat from traditional order.)

21. Magnetism
22. Electrostatics, useful to understanding of nature of electricity
23. Nature of Electricity, Electrons, Crooke's Tube, etc.
(Topics 24 (Ionization) to 27 are chemistry topics.)

I am not asserting that this course is no better than its precursors. In fact I am quite sure that it is considerably better. All I am saying is that the course would have been better still if they had chosen to organize it less atomistically. The sanctions for the course unfortunately seem to derive from the disciplines of the subject-matter fields of chemistry and physics rather than from concerns for the needs of young people.

What I am pleading for is not any one way of reorganizing and integrating the materials of the subject. In fact the more experimentation the better. I hasten to put in this disclaimer before putting forward my own plan. It should be understood also that it is impossible to justify, in the present article, all of the details of this outline. That justification must be reserved for later articles in this series. The outline is offered simply as one way by which the contents of the water-tight compartments may be interinfiltrated.

The Outline

The theme for the physics course shall be the story of man's use of energy, of his dependence upon energy at every phase and facet of his living, and of certain individual and social consequences which derive from his control of energy.[3]

I. Introductory. Energy phenomena. Short introductory unit that introduces the idea of energy without quantitatizing the idea and shows how energy may be transformed from one form to another.

II. Energy Forms Directly Used by Man.
   A. Sound—considerable expansion over usual treatment to show the social effects of noise, the physiology and psychology of hearing, sound as a form of energy, the science of music.
   B. Light—increased emphasis upon color and the physiology and psychology of vision; decreased emphasis upon manipulation of lens formulae.

III. How Energy Is Used by Man in the Work of the World. The story of this unit is roughly that told in: Hodgins and Magoun, *Behemoth.* Takes from the field of mechanics the section on machines, the concepts of efficiency, power, work etc. Includes the social effects of the machine. Then goes on to the various heat engines and other prime movers. These are largely devices for the conversion of the potential energy of fuels into useful work. The story of the development of the relationship between heat and work is stressed. Finally, in connection with the question of how energy is transmitted, electricity is considered, the question of how it is produced and why the present age could not develop until this form of energy was brought under man's control is finally considered.

IV. How Electrical Energy Is Used in Transportation and Communication. The nature of electricity would be discussed here since it is necessary to understand certain phases of the unit.

V. The Energy of Moving Bodies. Newton's Laws, Gravitation and Accelerated Motion are treated here. Some consideration of the Solar System is involved since the Laws of Gravitation were derived from a study of the motion of some of its members. The notion of energy may be made more precise at this point and the Laws of Motion used as a basis for a consideration of what constitutes sane driving.

VI. Energy and Matter—molecular forces, capillarity and surface tension.

VII. How the Earth Receives Its Energy from the Sun. Radiation from the sun and the results of the earth's absorption of this radiant energy. Heat is the most important effect. Heat-death and the end of the universe—an interesting speculation.

This outline is probably not ideal. In fact it cannot be so, since we agreed to a convention that prevents the best of integration—we are preserving physics as a separate subject. The merits of the outline seem to be at least two—it does afford the

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[3] The use of this "energy theme" has been discussed more completely than space permits here, in the following articles:

Brown, H. Emmett, "Some Educational Implications of Recent Developments in Science," School Science and Mathematics, 33: 490–505; 1933 (May).

Brown, H. Emmett, Evans, Hubert M., and Bingham, N. Eldred, "Science in the Junior and Senior High School." *Teachers College Record*, 37: 407–13; 1936 (Feb.).

opportunity to teach virtually all that is now taught in physics (assuming that this is a merit) and it does effect an organization of subject matter about a central theme. Omissions of certain bits of traditional subject matter may be noted. This is due to intent rather than to oversight. If such be treason, make the most of it!

A NEW DEVICE FOR TEACHING THE OPTICS OF THE EYE

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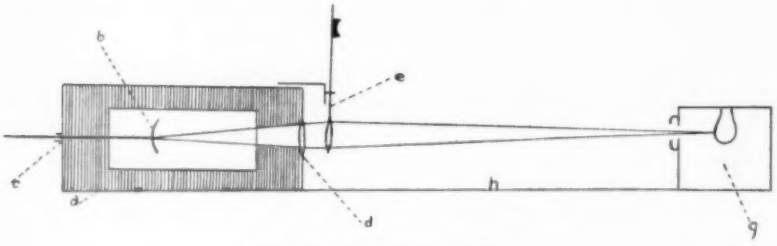
Experience in the presentation of human biology to both high school and college students has indicated that nearly everyone is fascinated by a description of the physiology of the eye. On the other hand, however, it has been observed that the fundamental principles are vaguely understood. To aid in the description and presentation of the optics the simple device pictured and described has proven very satisfactory.



THE EYE-MODEL IN USE

A one gallon can (*a*) mounted on a base (*h*) serves to represent the interior of the eye. A large rectangular window (*f*) is cut from the side of the can so as to permit a clear view of the light rays as they appear within the "eye." The interior is filled with smoke from a smouldering cigarette, incense, punk or any slow burning substance. The window is covered with heavy cellophane to prevent the escape of smoke. A movable retina (*b*) mounted on a long rod which slides in a guide (*c*) makes it possible to change the length or depth of the "eye." A biconvex lens is mounted in a slot at (*d*). The "crystalline lens" brings the rays of light emanating from (*g*) to a focus on the retina (*b*).

This model serves to demonstrate clearly many optical phenomena which are usually a mere mass of lines on the blackboard unless the student has mastered his physics. With the retina in a normal position for a lens of a given focal length the emmetropic (normal) eye is readily demonstrated. Within the smoke filled cavity the light rays can be seen to converge to a point or series of points upon the retina. The "eye" may be lengthened (made myopic or nearsighted) and the rays can be seen to diverge after having come to a focal point and thus cause a blur upon the retina.

By changing to a lens of different curvature at (*d*) accommodation may be affected and the focus carried back to the retina. The reverse may be arranged if the retina is moved forward from its normal position thereby causing the rays to strike it before a focus is reached as in hyperopia (farsightedness). Extreme cases of these defects may be illustrated by placing the retina beyond the focal points of the lens used in (*d*) and the correction made by swinging the proper correcting lens (concave or convex) into the proper position by rotating the wheel (*e*). This gives the effect of placing glasses before the abnormal eye to relieve the strain of accommodation. Astigmatic lens may be used at (*d*) and also corrected as mentioned above.

If a card with the letter L cut in it is placed in front of the lamp the inverted image is readily observed.

AMERICAN ASSOCIATION OF JUNIOR COLLEGES

The twentieth annual meeting of the American Association of Junior Colleges will be held at Columbia, Missouri, February 29 and March 1 and 2, 1940. The initial conference which resulted in the organization of the Association was called by Dr. George F. Zook, then specialist in higher education in the United States Bureau of Education, and was held at St. Louis in June, 1920. Quite appropriately therefore Dr. Zook, now president of the American Council on Education, has promised to give the principal address at the commemorative banquet which will be a special feature of the Columbia meeting. As many as possible of the 34 educators who composed the original conference will be present as guests of the Association on this occasion. Stephens College and Christian College, two well-known junior colleges for women, located at Columbia, will act as joint hosts for this important meeting. The American Association of Junior Colleges now has more than three hundred institutional members. Byron S. Hollinshead, president of Scranton-Keystone Junior College, Pennsylvania, is president of the Association.

MATHEMATICS AND DEMOCRACY

P. H. NYGAARD
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So many definitions of democracy have been given that to propose another may lead only to increased confusion. Nevertheless it shall be our purpose to accept this risk by contending that democracy is a mathematical form of government. In claiming that the principles of democracy are essentially mathematical, another hazard is involved—teachers of history and civics may not take kindly to the idea of having mathematics trespass on their preempted territory.

Instead of becoming alarmed, however, the social studies people should be pleased to accept such an alliance. Before the advent of Galileo and Newton physics was almost devoid of mathematics; its remarkable progress during the past three centuries has been largely due to its increased utilization of mathematical techniques. During this same time chemistry and astronomy have undergone similar changes. Since the beginning of the twentieth century psychology, pedagogy, biology, agriculture, and business administration have also been invaded by the mathematicians with gratifying results. Teachers in all these fields take pride in thinking about their subjects as exact mathematical sciences. It would, therefore, seem that the analysis of social problems might also benefit from a closer association with mathematics.

In discussing the mathematical aspects of democracy let us first direct our attention to the simplest, and historically the earliest, interpretation of democracy—namely, government by the will of the majority. Issues in a democracy are decided, not by the accidents of hereditary birth, not by the whims of a dictator, nor by the brutal forces of war. They are decided by an appeal to the magic of mathematical counting. People are elected to office and laws are enacted in our legislative bodies by the simple expedient of counting heads. As fractions are not recognized in this tallying of numbers, there are no half citizens or double citizens. In theory, at least, all are equal, and each is an indivisible, individual unit. From this standpoint democracy is an direct application of the mathematics of integers.

In fact it is probable that early democracy operated originally under a type of mathematics still simpler than counting. Suppose that a group of our barbaric ancestors were sitting around

a council fire trying to decide whether to move their camp or to remain at their present abode. They might indulge in much finger pointing and guttural ejaculation. Without knowing how to count they would, nevertheless, probably decide the question by the democratic principle of majority control. Each man in favor of moving would be matched, or offset, by a man in favor of staying. This pairing would continue until one of the sides was used up. The other side would then be the winner. Such was probably the first application of mathematics to democracy.

This primitive pairing process, it may be interesting to note, is still used by United States congressmen and small children. If a United States senator can not be present to vote in favor of a certain bill, he hunts up a senator who is against the bill and they both agree to stay away. Small boys sometimes still settle the question of who has the most marbles by each taking one at a time from his pile until there are marbles left in only one pile.

It is not such a far jump from this matching method to our modern ballot counting. The only significant difference is that a number, or counting, system has been developed. The evolution took place roughly as follows: Instead of pairing the actual men against each other, the pairing was done on the fingers; one man would be indicated by one finger, two men by two fingers, and so on; from this finger reckoning ten numbers finally came into use corresponding to the ten fingers on a man's two hands; from these numbers grew our decimal notation. Whether decisions in a democracy are made by the primitive matching used by our early ancestors, by counting bits of pottery as was done by the Athenians, by oral ayes and nays as in the New England townmeetings, or by the latest voting machines, the fact remains that the human beings arrayed against each other are considered to be mathematical integers.

You may wish to remind us at this point that democracy, after all, is much more than just counting votes. Does mathematics enter into any of the fundamental ideals and objectives of democracy? It certainly does. Among the basic goals of democracy are justice and equality, the achievement of which is necessarily bound up with the mathematics of measurement.

The crude measurement methods based on the human body were sufficiently fair and uniform for the simple relationships of primitive democracy. A man's foot did not change a great deal from maturity to death, nor were the feet of his neighbors

so much different from his own. The same can be said of the length of a man's arm, the length of his stride, and other similar units. However, as trade and intercourse between people increased, arguments continually arose as to whose arm should be used in measuring cloth, whose foot should be used in stepping off the length of a log, or whether the tax collector had used too short a stride in measuring a taxpayer's land. Since such inequalities could not be tolerated in a democracy, governments were gradually forced to set up more mathematically accurate standards and tables of values. In this connection it is significant to remember that one of the first acts of the democracy swept into power by the French Revolution was to establish the splendid metric system of measurements.

Most of the numerous laws and commissions in a modern democracy are intended to regulate the affairs of men in the interests of justice and equality. To secure these ends in our complicated civilization is impossible without setting up mathematical standards for human conduct. An examination of our governmental activities shows a surprisingly strong undercurrent of mathematics. Taxation involves uniform valuation of property and computation of rates. There are government inspectors to ensure that merchants have scales that give correct weights, that service stations have gasoline pumps that dispense accurate gallons, and that produce dealers do not sell eggs whose air cells exceed a certain diameter. Laws are passed limiting the number of miles per hour an automobile may move and the number of hours it may remain stationary, prescribing how many feet from a hydrant it may be parked, how many people its front seat may contain, and what angle its headlight beam may be inclined to the road. An employer must be careful that the number of hours worked by an employee in a week does not add up to more than a certain figure, and that the pay must exceed another figure. The government is much interested in the exact number of acres of wheat or cotton seeded by a farmer. Apple growers are forced by law to spray their orchards at stated intervals, but are denied the right to sell their apples if the spray residue adhering to them exceeds a certain minute percentage. The Federal Communications Commission has such exacting standards that radio station operators dare not let their carrier wave deviate from the assigned value of its time per cycle by as much as one billionth of a second. A fisherman must be careful not only in counting his fish but also in measur-

ing their length. In burlesque shows and on the bathing beaches the number of square inches of bare skin is a matter of some concern. Persons who score less than an I. Q. of 60 on an intelligence test are subject to institutional confinement. In many states a person's right to marry is decided by submitting a sample of his blood to the exact measurements of the Wassermann test. Pedestrians on city streets have their stops and starts timed for them to the fraction of a second by electric signalling devices.

All of these illustrations, and the hundreds of others that could have been mentioned, may seem to some people to be ridiculous attempts of government to interfere with the rights of the individual. Behind every one of them, however, is a genuine effort to ensure justice and equality by evaluating conduct in terms of precise mathematical equivalents.

To see this more clearly consider the attitude of democracy toward alcoholic intoxication. The conduct of a person under the influence of liquor is limited to prevent him from causing injustice to his fellow citizens. He may not, for instance, legally drive an automobile. The determination of whether a person is intoxicated has, until recently, been left to haphazard tests; law enforcement officers smelled his breath, or listened to him talk, or watched him walk. Now they are beginning to use more accurate methods—such as having him exhale an exact number of cubic centimeters of air, measuring the amount of alcohol in this sample, and then by means of graphs and charts determining the degree of his inebriety with justice to all concerned.

Two concepts of democracy have thus far been analyzed. First, it was shown that popular sovereignty is essentially a numerical principle. Secondly, the struggle of democracy for justice and equality was found to lead to mathematical interpretations.

Democracy's third stage is a deliberate, cooperative effort to secure the greatest good to the greatest number. Whereas the popular sovereignty stage was intrinsically neutral as regards objectives and the justice and equality stage tried to achieve its ends by negative limitations, the recent trends have been toward positive planning and integrated action. The scientific and mechanical developments of modern times are forcing us to remake our whole mode of living. In the face of such huge complexities, individual action is futile, and governmental action for the good of all is extremely difficult. To under-

stand how the radio works is hard enough, but to evaluate all its interactions so that it may be properly utilized for the benefit of society is infinitely harder. Yet it is this latter problem which democracy must attempt to solve. Dictators, emperors, and military leaders can set up radio stations, build roads and factories, carry on war, organize educational systems, and control labor and industry without measuring values and relationships. Democracies must deliberately plan such activities for the general welfare, and must use mathematics widely in drafting the plans. Just as surveying and calculating must be thoroughly done before a large bridge can be built, so also must democracy do much measuring and figuring before it can erect its bridges to the promised land.

Our government's monetary policy is an illustration of attempted mathematical planning for the greatest good to the greatest number. Westerners think of a dollar as a heavy silver coin, but it is legally an exact number of grains of metal 90% of which is pure gold. To secure fairness between the demands of creditors for a big dollar and of debtors for a small dollar, the gold content in the definition is sometimes altered. To control credit, changes are made in the re-discount rate, or the available supply of gold reserves, or the ratio of reserves to currency. Many economists insist that full justice will not be secured until the value of the dollar is based on index numbers computed by algebraic formulas from commodity price statistics.

Another scheme designed to increase the general welfare is the federal social security set-up. A large percentage of the wage earners in this country are serial numbers in the accounting files of this pension plan. Its successful administration requires complicated bookkeeping, millions of compound interest calculations, extensive use of actuarial estimates, and a thorough application of the theory of probability to such questions as technological unemployment, future population trends, and the cost of living.

The idea of a planned society is repulsive to many people. In it they see a complete engulfment of liberty in the rigorous security of mathematical regimentation. On the contrary, increased security is likely to enhance the feeling of liberty. If the planets of the solar system were permitted to move at random, their liberty of motion would be purchased at the expense of constant fear of collision. Moving as they do about the sun in approximately concentric circles of different radii, their

motions are restricted by mathematical laws so that there is not only more security but also more liberty to continue without interference. Similarly, the mathematics and science used in social planning would not eliminate liberty, they would eliminate only destructive liberty.

The problem faced by democracy in deciding whether a certain policy will, on the whole, be beneficial to its citizens requires for solution the ideology of integral calculus. This can be simply stated as follows: If y is a function of x and dx is an infinitesimally small part of x, then the definite integral from a to b of ydx means the algebraic sum of all products of the form ydx between the limits $x=a$ and $x=b$. Applied to the integration of society, y becomes the benefit derived, x the population, and dx each individual in the population. Thus, to evaluate the benefits arising from the Townsend plan it is necessary to multiply the number of people at each age level by the amount of benefit each would derive and then find the total of all such products—in other words, integrate the benefits to all the people between the age limits of infancy and old age. The big hump in the upper ages will probably be more than counterbalanced by the negative benefits in the wage earning years. Whether the Coulee Dam is for the general welfare will depend on the summation of its benefits to all people between the geographical limits of Washington and Florida. Whether the federal income tax is beneficial will be found by totalling its benefits to all citizens between the income limits of pauperism and extreme wealth. Whether the government's agricultural policy is desirable can be determined only by integrating its benefits over the whole occupational range. The guiding light of mathematics is needed to penetrate the haziness and the bigness of such problems so that statistical data may be analyzed, trends may be compared, relationships may be understood, and research may be unbiased.

A word of warning is needed at this point. When the mathematician evaluates a definite integral, the dx's involved are docile infinitesimals that meekly follow the rules prescribed for them. The dx's that enter into the analogous problems of social integration are, however, living human entities that are charged through popular suffrage with the job of carrying on the integration. Are the individuals capable of this task? In other words, will not the self interest and ignorance of voters make a bungling mess of these problems?

To this there are two answers. First, the actual solution should be left to research experts who will, it may be expected, be more impartial, thorough, and far-seeing than ordinary citizens. Voters would then decide only whether a certain segment of society should be subject to planning and would leave the details to technical specialists. They would, for instance, decide whether there should be federal control of wages and hours, but would be content to let economists elaborate the plan. Stated differently, the voters would decide when and where mathematical co-ordination should be employed, but would not themselves apply the mathematics.

The second answer is that all citizens should be trained to understand at least the basic aspects of the mathematical approach to social and economic problems. They should sympathize with the objective procedure of experimental science and revere the ideal truths of mathematics. Since every adult citizen is a direct part of the counting process by which democracy arrives at its decisions, education in a democracy should impart to all citizens a comprehension of the mathematical methods that underlie both the complex mechanical civilization in which they live and the democracy which is trying to evolve from this complexity a greater amount of justice and of good for all of them.

22,000,000 CHILDREN

According to records of the U. S. Office of Education, there are approximately 22,000,000 children ranging in age from 5 to 14 in elementary schools, public and private throughout the country. They are taught by more than 650,000 teachers. Principals, supervisors, superintendents, and service employees swell the number beyond 700,000. The latest published figures available show that slightly more than half of the children in public elementary schools in this country attend school in a community of 2,500 population or less. They go to school approximately 33 weeks of the year at an average cost of $56.39 per child.

A leaflet entitled "Know Your Modern Elementary School" has been prepared by the U. S. Office of Education for those who wish to know more about today's elementary school. "Elementary education can be classed as big business from the standpoint of number of children enrolled and annual expenditure in dollars and cents," says the U. S. Office of Education, "and there is need for parents and all citizens in a community to know and understand the principles on which modern schools are organized."

THE DEPARTMENTAL LIBRARY IN A SMALL COLLEGE

GEO. W. MUHLEMAN
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Ralph Waldo Emerson is accredited with saying, "The measure of a master is his success in bringing all men around to his opinion in 20 years." I am inclined to agree with Emerson for the reason that science has proved that it requires about 20 years to crystallize a worth while idea and set it to work. Twenty years ago I proposed and purposed to begin the building of a Chemical Departmental Library. In the face of a tradition, which dogmatically stated that there never had been a departmental library, I, with a mere hand full of books of ancient vintage, began my organization. Other departments opposed the idea for the reason that if a book was needed for general reading it would be inconvenient to come to the department of chemistry for this particular book. Others of the provincial type of mind, opined that if the department of chemistry was allowed a departmental library then all other departments should be granted a like privilege. It was further pointed out that the librarian would have difficulty in making inventory of the library books if part of them were housed in another building. Then it was further objected to in view of the fact that it was not in accord with library practice and library organization. Fault was found with the term, "Departmental Library," as to whether it meant the Professor's private library housed, free of charge, in his own office or whether it implied that he actually owned the books which had been purchased with the funds of the institution. It also gave rise to the feeling that perhaps the department of chemistry was too aloof and felt it was a law unto itself and that it was dictating to the administration and to the institution. What did a professor of chemistry know about library science? How would he be able to prevent the loss of books and scientific journals? What did he know about card indexing? Which system of cataloguing was he going to use? The Library of Congress System or the Dewey System? The general library was open from 8:00 A.M. until 9:00 P.M., what was to be done about the student who suddenly discovered at about 8:30 P.M. that he had forgotten to draw out a library book in which he needed to do some reference reading? How were the volumes to be protected from theft, loss and corrosion

by chemical fumes? Were the students to have free access to the stacks? Were you to risk having a book marked QD returned to the shelf of books marked QP and have order transformed into chaos with the consequent expenditure of time, effort, and patience in correcting the faux pas? Should you risk permitting a student, unacquainted with the intricacies of library classification and technique, to have free access to browse as he might desire? Does the professor of chemistry have time or should he take the time to aid his students in their reference reading and incidentally give them instruction in how to use the library? Would it be humanly possible for a professor of chemistry to work under the supervision and direction of the head librarian? All of the above obstacles had to be surmounted, and many others too numerous to be enumerated in this paper and in addition the spirit of cooperation and good will had to be maintained through it all. As a climax to this 20 years of endeavor the writer of this paper was elected chairman of the library committee of Hamline University and President of one of the Branch Library Councils of the City of St. Paul. I wish to publicly declare that as a rule librarians seem to be endowed with more heavenly graces than is vouchsafed to most mortals. They can teach departmental heads much that is of value in the way of orderly work and orderly thinking. It is in order to suggest that members of faculties are obligated to better acquaint themselves with library work even though they do not propose to organize a departmental library.

As an aid to the realization of this goal, the main purpose of a text book should be to initiate the student into the use of a library. The aim of most of the authors of the modern text books in chemistry seems to be that of making their texts libraries in themselves. The result is that the student is so crowded for time to master the subject matter, that he finds it impossible to do much original reading and thinking in the library. If the professor of chemistry introduces subject matter not included in the text then he is accused by his students of digression and not adhering closely to the confines of the text in the hands of the student. This criticism of chemistry teachers prevails from coast to coast. A text book is a veritable handicap to both teacher and student. The very significance of the term, "text book," has been lost sight of. Usually a speaker on a religious theme selects his text from a certain book in the Bible and then wanders far afield in his reading to find material for

his address. The writers of text books, judging from the length of their appended bibliographies, follow the same method of procedure with this distinction that they are more discriminating in the selection of their subject matter and in that they scan heaven and earth and the waters of the deep to secure the information for which they seek. Why should not the author of a text or the teacher of a text organize his work so that the student may have the experience as well as the satisfaction of gleaning from many texts rather than from one author's compilation? If the student in a departmental library is permitted to do reference reading, in chemical treatises such as Mellor, and of the many monographs and annual reports he will assuredly gain a much broader conception of the term text book. By simply referring to the subject index of *Chemical Abstracts* the student early in his course gains a different idea of how the knowledge found in text books is acquired. Critics state that text books in science become out of date in a few years. This assertion simply means that science text books are not generally used as keys to the current literature. It further gives the wrong impression that all of the old knowledge is to be discarded and that its acquisition represents wasted time and energy. It fails to state that all new knowledge has evolved from the old and that one of the important assignments to the scientist is that he study critically old truths for the purpose of discovering error and by this critical study to discover new truths.

My conception of a departmental library then has been built around the idea of providing supplementary reading for the different courses offered to undergraduate students in a small college. Every small college registers students who plan to prepare for various industrial and professsional careers. The average high school student has been propagandized by popular and professional chemical literature. When he comes to college many of the conceptions which he has gained from rather careless reading must be corrected by supplying him with standard chemical literature. Publishers do a faithful and thorough piece of advertising of all worth while new books. The head of a chemistry department with a limited sum of money to spend annually for books can in 20 years, by judicious selections, build up a worth while library that can be utilized in a telling way in preparing the high grade student for the graduate school. The library and the laboratory must be taught together. One can not be separated very far from the other.

There are standardizing bodies in these days for colleges as well as for libraries and laboratories. Recently our library was awarded $10,000 from the Carnegie Corporation. This gift required that books in all departments of the college should be checked against a standardizing list[1] and those books not owned by the college should be purchased from the funds made available by this gift. The two methods therefore have resulted in building up a list of fairly complete reference books and texts. According to the Key Classification of the Library of Congress our departmental library contains books in science under the following headings:

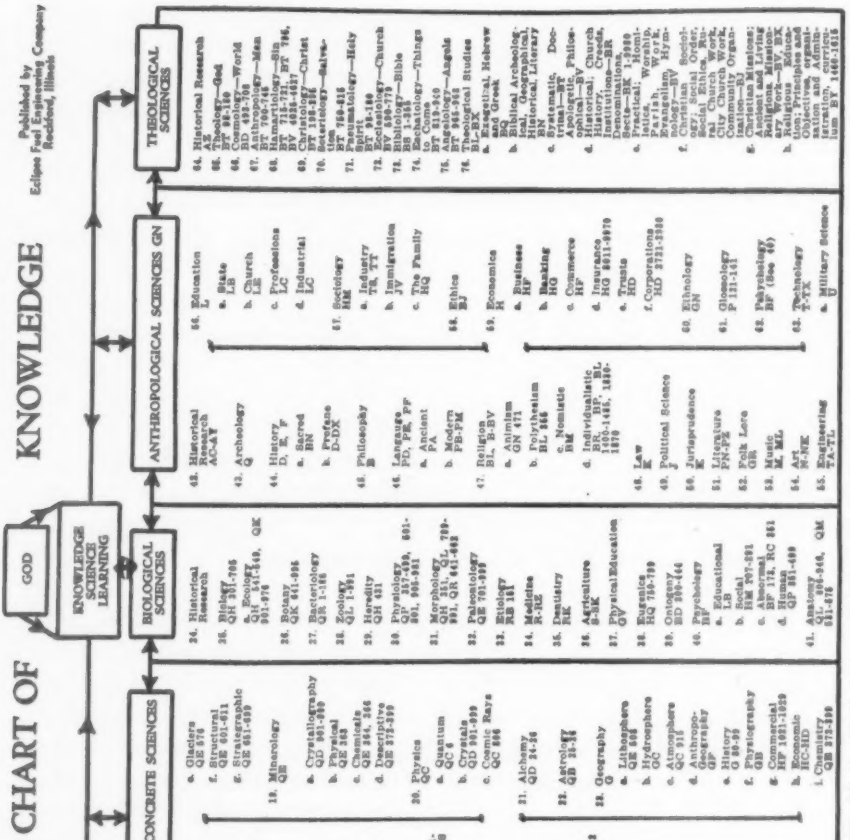
S, Agriculture
SF, Dairying
T, Technology
TD, Sanitary Engineering
TL, Motor Vehicles
TN, Mineral Industries
TP, Chemical Technology
TR, Photography
TS, Manufacturers
TX, Domestic Science
UG, Military Engineering
GV, Physical Fitness
HD, Petroleum
HM, Progress in Science
HV, Tobacco and Physical Health
ND, Artists and Colors
Q, Science
QA, Mathematics
QB, Astronomy
QC, Physics
QD, Chemistry
QE, Geology
QH, Natural History
QK, Botany
QP, Physiology
QR, Bacteriology
R, Medicine
RA, Hygiene, Toxicology
RB, Pathology
RC, Practise of Medicine
RM, Diet and Disease, Hormones
RS, Pharmacy.

We have all of the Journals of the American Chemical Society included in the $20.00 subscription and in addition the *Journal of Chemical Education*. Other periodicals include the *Journal of Biological Chemistry*, *The Scientific Monthly* and the *Helvetica Chimica Acta*, which affords opportunity for the students to read chemical literature in the French, the German and the Italian. Many trade journals come to my desk which contain material of real merit and are deserving of mention in this paper: *The Laboratory*, *The Chemist Analyst*, *Synthetic Organic Chemicals*, *The Merck Report*, *Library Service College Edition (G–E)*, *The DuPont Magazine*, *Bulletins from the Rockefeller Foundation*, *The Educational Focus* and numerous bulletins from scientific supply houses.

All of the standard periodicals are bound and kept in the departmental library. The Freshmen students are initiated into

[1] "A List of Books for College Libraries 2d ed. 1931."—Chas. B. Shaw.

the method of reference reading by using the *Author and Subject Index of Chemical Abstracts*. No doubt you will all agree with me that no journal has a more excellent scheme of classifying human knowledge than that adopted by the editors of *Chemical Abstracts*. Few text book writers can compare favor-


Compiled and Copyrighted, 1934, by Prof. Geo. W. Mathieson Hamline University
THE CHART OF KNOWLEDGE
Published by Edison Fuel Engineering Company Rockford, Illinois
GOD
KNOWLEDGE SCIENCE LEARNING
MATHEMATICAL or ABSTRACT SCIENCES
PHYSICAL or CONCRETE SCIENCES
BIOLOGICAL SCIENCES
ANTHROPOLOGICAL SCIENCES GN
THEOLOGICAL SCIENCES
Culture is a Knowledge of the best thought of the world; knowing something about everything and everything about something.

ably in their preparation of a workable index. The scientist insists upon two dogmas: First, the possession of a great deal of very accurate knowledge and techniques; Second, the knowledge of sources of valuable information. Chemistry teachers who rightly understand their mission will adhere very tenaciously to these two lines of teaching. Of course there should be a reasonable balance between library reading and laboratory assignments. But the student who contemplates graduate study in chemistry needs to be trained in the above procedure, otherwise he may be subjected to very humiliating handicaps.

Many treatises in analytical chemistry have been provided for the sophomore students and they are expected to make reports on articles appearing in *Industrial and Engineering Chemistry* and in *Chemical Education*. Those who can read the French and the German find material in *Helvetica Chimica Acta*. Students in third year chemistry are encouraged to use the reference books and are given definite assignments in the *Journal of the American Chemical Society*. We offer a course in Physiological Chemistry at Hamline because we have found this to be an excellent introduction to the literature of chemistry, a very excellent summary of four years of study in chemistry, a good introduction to graduate study and best of all a course which relates chemistry in a small college to the department of Biology, Physics, Bacteriology, Botany and to Medicine, Dentistry, Physical Education, Dietetics, Industry, Economics and to Government. The *Journal of Biological Chemistry* is very thoroughly reviewed as well as many of the different text books and monographs which have been purchased for our departmental library. For 20 years we have had a Chemical Seminar open to students who have elected chemistry as their major. The sole purpose of this course is to enable students to do additional reading in the fields in which they have demonstrated marked interest and ability. They report on one of the new books, or on a monograph, or on a research paper or they are given a topic which requires reference reading. After they have exhausted the literature in our departmental library they then make use of the public libraries of the Twin Cities and The James J. Hill Reference library. It may be of interest to point out that the law library in the Minnesota Capitol building contains many volumes which have been written on specific chemical phases of legal thinking. The Ramsay County Medical Society also has a very excellent library open to the public. Our St. Paul Branch

libraries supplement the departmental reading by the purchasing of duplicate copies of standard texts.

Recently I made a rather critical study of our departmental library to discover whether we were accumulating "library lumber" or whether we were purchasing books which were never read. The study revealed the fact that books were drawn out from one to forty or more different times. Fifty readings of a book in the hands of the reading public usually wears out the book so that it either has to be rebound or thrown into the discard. We have in a number of cases had to rebind and in many cases have had to do repair work.

President Conant of Harvard University has pointed out that science men on the same campus are so departmentalized that they know very little about the subject matter of some of the sciences which are very closely related to their own field. To illustrate, I heard a physical chemist ask a biochemist to give him the formula for cystine. A teacher of undergraduate students will if he is not careful become so provincial in his departmental thinking that he may prejudice his own students against all other sciences. As an aid to my own thinking and as an aid to teaching I have constructed what I am pleased to designate as The Chart of Knowledge. I am obligated to the Eclipse Fuel Engineering Co., Rockford, Illinois for having published this chart and for having supplied me with extra copies. When I read a new book I judge the mind of the author by the number of different fields of knowledge upon which he draws for his writing. This chart has been approved by the Librarian of the University of Minnesota and the Library of Congress Librarian and disapproved by others who state that they do not know what it is all about. It is an attempt to classify all known knowledge under five headings, Mathematical or Abstract Sciences, Physical or Concrete Sciences, Biological Sciences, Anthropological Sciences and Theological Sciences. The Call Number used by the Congressional Library follows each division under the several headings and the numbers after the call number indicates the number of divisions of one special subject. The call number of chemistry is QD and there are 999 "varieties"; the call number of denominations or sects is BK and the number of varieties is 9980. I have aimed in this chart to show the relation of all fields of knowledge and to point out the small portion of the entire field of knowledge which is included or encompassed in any one special field. It gives the beginning student somewhat

of an idea as to the importance of laying a broad cultural foundation before he launches into a special field or a professional field. The three words at the top of the Chart—Knowledge, Science, Learning, have very little significance to the casual reader but when looked at in this sort of tabulation at least an inkling may be obtained as to their inclusiveness. "Culture is a knowledge of the best thought of the world; knowing something about everything and everything about something." I have aimed to represent the stream of knowledge as having a resemblance to the circulatory system of a living being. As comparisons may at times be odious I need no go farther in my comparisons.

Methods of teaching must be judged by results, even though the judgment may seem to be harsh. In 20 years approximately 1600 students have registered in beginning chemistry at Hamline University. Of this number 7% have majored in chemistry and of the 7%, 33% have earned advanced degrees, 12% of which were Ph.D. degrees. These Ph.D. men and women have found places in high grade positions in industry, on university faculties, in research laboratories, in administrative positions and in the employment of the United States Government. It is to be noted that they have carried with them the idea of scholarship. It can be said of the profession of chemistry that no matter what the reward may be its aim is excellency and excellency is one of the highest moral qualities towards which the human mind aspires. Bacon a long time ago stated that reading maketh a full man and writing an accurate mind. Reading chemical literature will develop the critical mind but unless the chemist teaches writing also I fear that chemistry will not be written in a language which is for the reading public. A departmental library in chemistry is little used by the other departments of a small college therefore teachers of chemistry in a small college who have not organized their own departmental library have committed two errors (1) they have deprived their own students of the full use of a special literature (2) they have not made full use of library facilities at their special disposal and furthermore are not making the chemical literature pay dividends on the money invested.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

SOME EXPERIMENTAL DATA ON THE RELIABILITY OF TEGOSEPT M. AND MOLDEX AS MOLD PREVENTATIVES IN CULTURE MEDIA

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Wright Junior College, Chicago, Ill.

Tegosept M. and Moldex are chemicals in powder form used by geneticists as mold preventatives in culture media. The general practice has been to add one gram of Tegosept M. or Moldex to every 1000 cc. of medium.

The author has been interested in mold preventatives because they represent aids in the teaching of laboratory genetics. The objection to most chemical mold preventatives is that they tend to reduce the size of the population. The purpose of this paper is to present experimental data concerning the relation between Tegosept M. and population, sex-ratio, and Mendelian ratio; and to show the influence of Moldex and autoclaving on population and sex-ratio.

TEGOSEPT M.

A single portion of Standard medium[1] sufficient for twenty cultures was divided into two equal portions. Tegosept M. was added to one portion, which was distributed among ten bottles. Ten bottles containing media without Tegosept M. constituted the control. Twenty matings between red-eyed females (*Ww*) and red-eyed males (*w*-) were made. All of the cultures were kept in an incubator.

As Tables I, II, and III show, the results of this experiment indicate that Tegosept M. has no effect on population. The data also indicates that Tegosept M. is not a disturbing factor in relation to recessive characters, sex-ratio, and Mendelian ratio.

The experiment was repeated under identical conditions except that 48 cultures were used instead of 20. The results as shown in Table IV are similar to those of the preceding experiment.

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[1] Standard medium: 850 cc. water, 100 grams corn meal, 75 cc. Karo syrup, 75 cc. Brer Rabbit molasses, and 15 grams agar-agar.

TABLE I

SHOWING THE DISTRIBUTION OF THE PROGENY OF 10 MATINGS BETWEEN HETEROZYGOUS RED-EYED FEMALES (*Ww*) AND RED-EYED MALES (*W-*) RAISED IN STANDARD MEDIUM CONTAINING ONE GRAM OF TEGOSEPT M. PER 1000 CC. OF MEDIUM

Culture	Males (*w-*)	Males (*W-*)	Males (*w-*)(*W-*)	Females (*WW*)(*Ww*)	Total
1	19	35	54	52	106
2	30	23	53	62	115
3	31	20	51	51	102
4	24	26	50	57	107
5	29	33	62	65	127
6	28	36	64	66	130
7	22	31	53	60	113
8	26	26	52	54	106
9	34	29	63	55	118
10	24	26	50	61	111
Total	267	285	552	583	1135

TABLE II

SHOWING THE DISTRIBUTION OF THE PROGENY OF 10 MATINGS BETWEEN HETEROZYGOUS RED-EYED FEMALES (*Ww*) AND RED-EYED MALES (*W-*) RAISED IN STANDARD MEDIUM CONTAINING NO TEGOSEPT M.

Culture	Males (*w-*)	Males (*W-*)	Males (*w-*)(*W-*)	Females (*WW*)(*Ww*)	Total
1	29	27	56	58	114
2	28	24	52	50	102
3	23	29	52	63	115
4	21	24	45	64	109
5	26	32	58	57	115
6	28	32	60	59	119
7	22	32	54	53	107
8	31	29	60	57	117
9	20	28	48	58	106
10	25	21	46	61	107
Total	253	278	531	580	1111

TABLE III

SHOWING SOME COMPARATIVE STUDIES OF DATA SHOWN IN TABLES I AND II

Culture	Mendelian ratio white:red	Male ratio *w-*:*W-*	Sex-ratio Male:Female	Average population per culture
Tegosept M.	1:3.250	1:1.067	1:1.056	113.5
Control	1:3.391	1:1.098	1:1.098	111.1

TABLE IV

SHOWING SOME COMPARATIVE STUDIES OF DATA DERIVED FROM 48 MATINGS BETWEEN HETEROZYGOUS RED-EYED FEMALES (*Ww*) AND RED-EYED MALES (*W*-), 24 OF WHICH WERE RAISED IN MEDIA CONTAINING TEGOSEPT M.

Culture	Mendelian ratio white:red	Male ratio *w*-:*W*-	Sex-ratio Male:Female	Average population per culture
Tegosept M.	1:2.85	1.090:1	1:1.097	85.3
Control	1:2.86	1:1.097	1.106:1	90.5

The purpose of the next experiment is to determine whether or not there is any correlation between concentration of Tegosept M. and population, Mendelian ratio, and sex-ratio. Twenty-four cultures were grouped into six series of four per series. Each series contained a different quantity of Tegosept M. as shown in Table V.

TABLE V

SHOWING THE DISTRIBUTION OF THE PROGENY OF SIX SERIES OF MATINGS WHEN VARYING THE CONCENTRATION OF TEGOSEPT M

Series	Tegosept M.	Males (*w*-)	Males (*W*-)	Males (*w*-)(*W*-)	Females (*Ww*)(*WW*)	Total
1	0.4 g./1000 cc.	95	87	182	174	356
2	0.6 g./1000 cc.	73	109	182	153	335
3	0.8 g./1000 cc.	80	86	166	184	350
4	1.0 g./1000 cc.	114	108	222	212	434
5	1.2 g./1000 cc.	96	108	204	194	398
6	1.4 g./1000 cc.	100	95	195	212	407

TABLE VI

SHOWING SOME COMPARATIVE STUDIES OF DATA SHOWN IN TABLE V

Series	Mendelian ratio white:red	Male ratio *w*-:*W*-	Sex-ratio Male:Female	Average population per culture
1	1:2.74	1.09:1	1.04:1	89.0
2	1:3.59	1:1.50	1.19:1	83.8
3	1:3.37	1:1.07	1:1.10	87.5
4	1:2.80	1.05:1	1.04:1	108.5
5	1:3.14	1:1.12	1.05:1	99.5
6	1:3.07	1.05:1	1:1.08	101.75

The low average populations in Series 1, 2, and 3 is probably due to the presence of a small quantity of mold and bacterial growth in some of the cultures. All of the cultures of Series 4, 5, and 6 were totally free of mold. In Series 4, 5, and 6, where ideal experimental conditions exist, the data does not show any correlation between concentration of Tegosept M. and population, Mendelian ratio, and sex-ratio. In general, the results of this experiment support the findings of the previous experiments.

Moldex[2]

Moldex, as a mold preventative, is rapidly replacing Tegosept M. It is generally believed by those who have used Moldex that it does not effect population.

The purpose of this experiment is to ascertain whether or not it is necessary to autoclave the medium when using Moldex. If autoclaving could be omitted in the preparation of media it would greatly reduce the time and energy needed to prepare large numbers of cultures for class-room purposes. It would also reduce investment and cost of operation.

Table VII

Showing the Influence of Moldex and Autoclaving on Population and Sex-Ratio

Series	Number of cultures	Average number of males per culture	Average number of females per culture	Sex-ratio	Average population per culture
1. −Moldex −Autoclave	9	69.0	58.2	1.18:1	123.2
2. −Moldex +Autoclave	10	105.5	101.8	1.03:1	207.3
3. +Moldex −Autoclave	7	99.0	102.0	1:1.03	201.0
4. +Moldex +Autoclave	4	90.5	104.75	1:1.15	195.25

[2] Moldex can be obtained from the Glyco Products Co., Inc., 148 Lafayette St., New York City.

Russian raisin medium[3] was used in this experiment. This medium is rapidly replacing the Standard medium, because it yields a larger population. The cultures of Series 3 and 4, as shown in Table VII, have a concentration of 1 gram of Moldex for every 1000 cc. of medium.

The data, as shown in Table VII, indicate that autoclaving is unnecessary when using the Russian raisin medium containing 1 gram of Moldex per 1000 cc. of medium. The low average population per culture in Series 1 is probably due to the presence of mold and bacterial growth that developed in the cultures. There was no mold in Series 2, 3, and 4.

SUMMARY

1. Tegosept M. seems to have no effect on population.
2. Mendelian ratios and sex-ratio are not affected by Tegosept M.
3. Russian raisin medium provides a greater population yield than Standard medium.
4. Russian raisin medium does not affect sex-ratio.
5. Autoclaving (or any other method of sterilizing) is unnecessary when using Russian raisin medium containing a concentration of 1 gram of Moldex for every 1000 cc. of medium.

[3] Russian raisin medium: 800 cc. water, 50 grams corn meal, 25 cc. Karo syrup, 25 cc. Brer Rabbit molasses, 15 grams agar-agar, 40 grams ground raisins, 15 grams dry yeast (or 120 grams fresh yeast), 1 gram of Moldex.

A TRIBUTE TO PROFESSOR BRESLICH

"Zeta Chapter of Phi Delta Kappa, national professional education fraternity, has published a special issue of its bulletin *Zeta News* reviewing the contributions to education of Dr. Ernst R. Breslich, who retired from the department of education at the University of Chicago this summer.

"A limited number of reprints has been made available to teachers of mathematics and friends of Dr. Breslich without charge. Requests should be addressed to Zeta Chapter, Phi Delta Kappa, Department of Education, University of Chicago.

"Features of the issue include a discussion of Dr. Breslich's contribution to mathematics education by Professor W. D. Reeve of Teachers College, Columbia University, Professor W. C. Reavis of the University of Chicago, and George E. Hawkins of the University High School, Chicago. Dr. Breslich himself has written an article reviewing the development of mathematics teaching. A photograph, biographical sketch, and bibliography are also included."

SEEKING FORMULAS FOR TABLES OF RELATED VALUES

LAURA BLANK
Hughes High School, Cincinnati, Ohio

In the larger school systems, usually classes are graded as to I. Q. or percentile rank, or as to earlier achievement in a subject in the same field of study. Consequently there may be as many as four levels of ability in as many classes. The group of highest possible achievement should be one of our most challenging educational studies. To be honest with ourselves, we must admit that we probably put our least efforts and energies there, for they will pass the course of study, with a minimum of our guidance. Moreover the mediocre group, or *X*-group so exhausts our plans as to subject matter and method and individual need that only occasionally do we scintillate, send sparks that reach latent powers in our highest ability group.

In a beginning course in algebra the attempt to work from a table of related values to a formula or verbal statement of conditions is an experience perhaps little developed. Yet reasoning of this kind is of our most valuable experiences in life as intelligent individuals. Thinking that makes for progress whether in the purely scientific field, of the research type, or of a more general character, is of the analysis, then synthesis type. Consider the work of the Mellon Institute of Pittsburgh, an organization of diagnosis, its thought processes are of this type: analysis many times repeated, then attempts at synthesis. Theirs is no simple, fortuituous trial and error endeavor to determine conclusions.

Is not much serious human thinking an effort to find patterns, patterns of things, patterns for social relations, for human conduct? Is not the highest idealistic, spiritual form of endeavor, the effort to find the divine purpose and plan, pattern for one's own life? Moses, in Hebrews 8:5 was told: "See that thou make all things according to this pattern showed to thee on the mount." This life design was to be made effective and operative in human life. Our upper intellectual stratum, no doubt, contains many of our leaders of the immediate future. They may remake the world.

Our class is one in elementary algebra or general mathematics. All effective teaching of algebra to-day is, to some degree, of the nature of general mathematics; Simon pure algebra

belongs to previous decades. Our class has progressed in our course of study, or unit, if you prefer, so as to be able to translate a simple formula into a table of appropriate and related number values. Perhaps the pupils have developed formulas from verbal statements, and, then from the formulas, tables. Many such relations can be profitably studied. There are those involving uniform speed of travel, uniform cost of articles, those concerning areas and volumes, and those involving averages. There are many more sorts.

Now, conversely, to develop formulas from tables of related values, that is a much more difficult reasoning process, the acme of scientific endeavor.

Let us consider problems graduated in difficulty:

There remained in a storage tank only 18 gallons of water on a certain day. It was then filled at the rate shown in the following table:

Number of minutes =	0	1	2	3	4	5	8	12
Number of gallons =	18	30	42	54	66			

Develop a formula for the number of gallons in the tank after any given number of minutes, using g and m.

The parcel post charges for the third zone (from 150 to 300 miles) are represented by the table:

Number of pounds =	1	4	5	8	12
Number of cents =	9	15	17	23	31

Evolve a formula expressing the cost c of p pounds.

The rate on telegrams to a certain town is represented by the following table:

Number of words =	10	12	15	20
Number of cents =	50	56	65	80

Express as a formula the cost, c, of w words.

From the table below, develop a formula which will tell how y depends upon x:

x =	1	2	3	4	5	6
y =	2	0	-2	-4	-6	-8

The following table represents the cost in cents of sending parcel post packages into the sixth zone. Derive the formula in terms of c and p:

Number of pounds =	1	2	3	4	5	6	7	8
Number of cents =	12	19	26	33	40	47	54	61

Formulas may frequently be obtained from tabular values by inspection, as we probably have been doing here. If, however, values appearing in the table are complicated, and it is expected that the formula be of the linear type, it may be found easily by using the equation: $c=mp+n$. In the example above $19=2m+n$, and again, $40=5m+n$. Solving these two equations in m and n, we find $m=7$ and $n=5$. Hence $c=7p+5$. We are presupposing a graphic understanding of the linear equation. However our formula may not be linear.

Develop the formula connecting x and y:

$x=$	0	1	2	3	4
$y=$	6	6.8	7.6	8.4	9.2

During certain weeks of a vacation period, a boy's savings in dollars increased as shown in the following table:

Number of weeks =	1	4	5	7	9
Number of dollars =	$3\frac{1}{4}$	$5\frac{1}{2}$	$6\frac{1}{4}$	$7\frac{3}{4}$	$9\frac{1}{4}$

Develop a formula in d and w.

Possibly we should close our study by presenting tables of values not in linear relationship, perhaps such as to produce quadratic formulas, or maybe no known formulas. Our young students, perhaps a bit conceited by their success in finding thought patterns among mathematical relations, need know something of humility. Yet, no one can be taught humility. It is a purely subjective experience. Perhaps no group of our present day thinkers knows it more convincingly than our great scientists. An example is the negro, George Carver, of Tuskegee Institute.

A poet once said as he plucked "a flower in the crannied wall," and gazed at it in his hand: "If I could understand what you are . . . I should know what God and man is."

A ROSE LINKAGE, TRISECTION, AND THE REGULAR HEPTAGON

ROBERT C. YATES
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Recently[1] R. K. Morley has pointed out the trisecting characteristics of the Four-Leaf Rose. The purpose of the present note is to describe the construction of a linkage which will trace this curve and which, of course, may act directly as a trisector itself. Although somewhat involved in a structural sense, it will not seem too bizarre to those familiar with the tortuous history of the Trisection Problem.

The root of the idea lies in the union of six bars jointed as shown in Figure 1.[2]

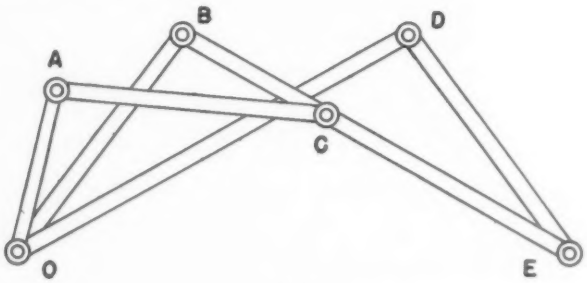

FIG. 1

The bars form *contraparallelograms* with

$$OA = BC = a;\ AC = OB = DE = b;\ BE = OD = c;$$

and angles

$$A = B = D;\ AOB = BCA;\ BOD = BED.$$

If we ask that angle AOB equal angle BOD throughout all deformations of the linkage then the two contraparallelograms must be similar, and conversely. That is,

$$OA/OB = OB/OD, \text{ or } b^2 = ac.$$

Thus, under this requirement, the bar OB at all times *bisects* the angle formed by OA and OD.[3]

[1] "A Trisection," *American Mathematical Monthly*, 39 (1932), pp. 230–231.

[2] This is a remarkable but simple mechanism devised by A. B. Kempe. See *Messenger of Mathematics*, NS IV (1875), pp. 121–124.

[3] Obviously, two more bars, OM and AN, may be joined to the smaller contraparallelogram in similar fashion so that OA will bisect angle MOB. This is the Kempe trisector.

This principle is applied in the apparatus displayed in Figure 2 where the bar NE is required by the contraparallelogram $NOKL$ and $HOMN$ to bisect the angle AOB.

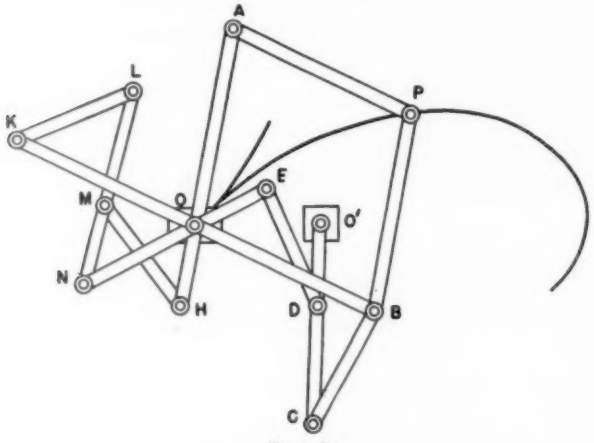

FIG. 2

A second pair of contraparallelograms, $OO'CB$ and $OO'ED$, fix OO' as the bisector of angle EOB. That is, if $\angle EOO' = \theta$, then $\angle AOB = 4\theta$ and $\angle AOO' = 3\theta$. The linkage is thus an obvious trisector.

If the *rhombus* $OAPB$, of side k, be completed and points O and O' be fixed to a base plane, it is apparent that P will move always in line with OE and generate the Four-Leaf Rose: $r = 2k \cdot \cos 2\theta$.

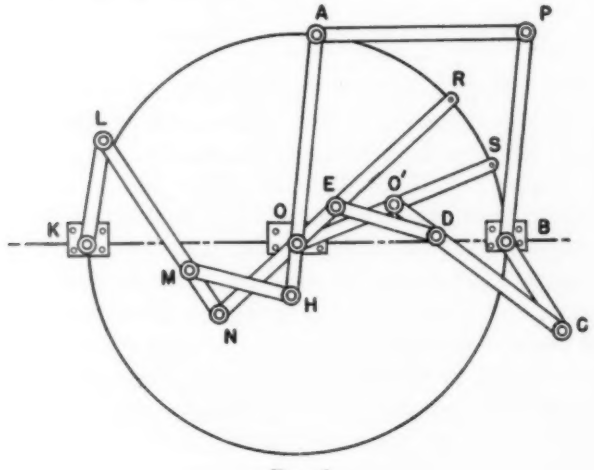

FIG. 3

If we release the point O' and attach B to the base plane, we have the mechanism shown in Figure 3.

The bars OE and OO' are extended to R and S so that OR and OS are each equal in length to the sides of the rhombus. Since $\angle AOR = 2 \cdot \angle SOB = 2 \cdot \angle ROS = 2\theta$, then the angles of the rhombus at A and B are

$$\pi - 4\theta.$$

Let the bar PB become coincident with the point S. Then triangle OSB is isosceles and the angle at B is

$$(\pi - \theta)/2.$$

For the linkage in this position,

$$\pi - 4\theta = (\pi - \theta)/2$$

or

$$\theta = \pi/7.$$

Thus, when the linkage is moved so that the point S falls on the center-line of PB the points B, R, and A are three adjacent vertices of the Regular Heptagon.

THE USE OF ASSEMBLED UNITS AS AN EFFICIENT METHOD OF STORING DEMONSTRATION APPARATUS

F. W. Moody
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One problem confronting many Physics teachers is that of finding sufficient case room for demonstration apparatus, or of arranging the apparatus in the cases, so that any piece may be quickly removed without disturbing the rest.

With deep cases this is not easy for in spite of all one may do, it may happen that the thing needed is in the back of the case, behind some other piece. Particularly, is this likely to be true where more than one teacher makes use of the room.

If the shelves are well filled, and one is to be able to reach to the back without disturbing things at the front, then the shelves must be widely spaced, which restricts the capacity of the case.

A scheme many find advantageous, is to have collections of

small items used for related topics, placed in long narrow boxes with suitable labeling, which will permit close spacing. Not all Physics apparatus, however, can be so stored.

In the December, 1936 issue of SCHOOL SCIENCE AND MATHEMATICS, we discussed the scheme of building assembled demonstration units. By mounting these on long narrow bases, cut to a length slightly less than the case depth, we find another partial solution of the case problem. An assembly can be planned on a base 4, 6, or 8 inches in width, which then occupies only a small length of shelf room and can always be withdrawn without disturbing anything else.

The plan utilizes practically all of the shelf area, enables one to keep available at all times any "pet scheme" a teacher has found satisfying, and permits a close spacing of the shelves, with just enough clearance for inserting the apparatus. It is noticeable, how much less crowded the cases seem, and how much more they will hold when this method is used.

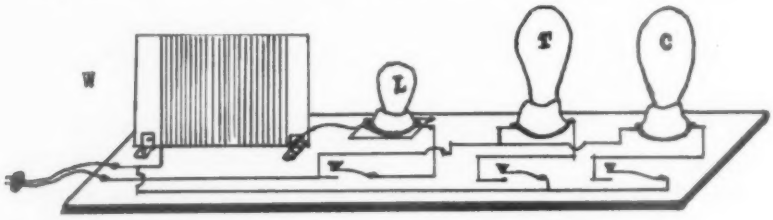
One assembly, developed since the publication of the previous article, is shown below. The idea is to have as many demonstrations as possible covering all phases of the subject, even though they are not all used with every class. It is very satisfying when a question is raised relative to some feature of class study, to be able to bring out a piece of apparatus illustrating the point under discussion. One usually feels that he has never quite clinched a point until he has given some visible demonstration of the principle in question. (The development of these assemblies may also be used as valuable construction projects for advanced students. Ed.)

This is a demonstration of the resistance change of a wire as it is heated. A coil of german silver wire, W, wound on a heavy sheet of asbestus, is supported beside a 6 volt automobile headlight, L; they are wired in series, and connected through a key to the line voltage.

The coil is of such length that its resistance permits three and one-third amperes to flow in the lamp and coil when the coil is cold. This is the normal current for the lamp and when the key is pressed, the lamp first glows with normal brightness. But as the wire heats up, the lamp gives off less light until after about one minute it shows less than half its initial brightness, clearly indicating the increased resistance of the wire.

To show the contrast of the action of a tungsten and a carbon lamp, two bulbs of the same size, T, and C, painted white to

make them look as much alike as possible, are wired to keys so that by pressing first one and then the other, either of the lamps may be lighted, or both may be flashed on at once. Attention may thus be directed to the sluggishness of the carbon lamp whose initial high resistance falls as it is heated with a noticeable time interval before it reaches full brilliancy. The tungsten lamp, however, flashes quickly, due to its initial low resistance.



Resistance change with temperature change.

HIGH LIGHTS OF THE DECEMBER SKIES

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[Editor's Note—This article is the second of a popular astronomy series. If these articles are saved from month to month, they will make a convenient handbook of star charts and teaching activities for secondary schools.]

In last month's "High Lights" we described ten well known constellations in the fall sky of "ten thousand lights."[1] Many of these configurations are still visible in the December sky, shifting their positions westward, and a few new configurations mark the arrival of winter and the holiday season.

I. CONSTELLATIONS AND STARS

A good starting point in the December sky is the constellation *Orion* which is rising from the southeastern sky. "The mighty hunter," as *Orion* is often called, is easily found as part of it appears like a diamond shaped key. The three bright stars forming the side of the key form the "Belt of Orion" and the three tiny stars that hang from the belt are pictured as

[1] The first article of this series appeared in SCHOOL SCIENCE AND MATHEMATICS in November, 1939, and described Pegasus, Andromeda, Taurus, Auriga, Perseus, Cassiopeia, Cygnus, Lyra, Aquila, and Ursa Major. Many of these constellations appear in the December sky.

the hunter's dagger. The brilliant star in the southwest corner of the constellation is *Rigel*, estimated to be 544 light years away. In the northeastern part of the constellation is *Betelgeuse*, a red star, which is approximately 300 times the diameter of the sun. It is much closer to us than its companion star *Rigel*, being about 200 light years away.

Also rising in the eastern sky is *Gemini*, "the twins," named for *Pollux*, and above it, *Castor*, the brothers of Helen, whose beauty was partly responsible for stirring the ancients into the Trojan war. Farther over in the eastern sky is the brilliant *Procyon* in the constellation *Canis Minor*, the "Small Dog." In the northern sky the "Big Dipper" in *Ursa Major* is drifting eastward gradually rising on its handle. Legend tells us that during the fall months, the dipper has been scooping cold water on its visit to the northern horizon and now returns to pour snow and ice on the earth as winter begins.

The *Great Square of Pegasus* is getting close to the western horizon and *Taurus* is about overhead sporting its brilliant star *Aldebaran* with the *Seven Sisters of the Pleiades* visible a little to the north. The *Pleiades* have been the subject of many fascinating legends and number among the few astronomical phenomena mentioned in the Bible.[2] *Auriga* continues to adorn the Milky Way with its principal star *Capella* twinkling in brilliance.

II. Planets

Like November, December is a busy month for star gazers, for *Saturn*, *Jupiter*, and *Mars* are still reflecting their steady beams on us, and *Venus* comes into view in the west. *Saturn* is often mentioned as the most beautiful of all planets for its brilliance and its famous rings. The "Rings of *Saturn*" are not a part of the planet as commonly supposed, but seem to be a mass of particles ranging from dust to rocks that whirl around the planet as it speeds along. The rings of Saturn are easy to see through a small telescope. *Jupiter* is much greater in volume and mass than any other major planet. Its brilliance and steady glare makes the planet easy to find, and one of the historical headstones of the December sky. *Mars* is sinking into the western skies and will soon be replaced by other spectacles of astronomical interest.

The Christmas season brings to the minds of thousands of people the "Star of Bethelem," for it is the selfsame sky that led the wise men to the town of Bethlehem over nineteen hundred years ago.[3] Astronomical data indicate that about this time a conjunction of *Saturn* and *Jupiter* occurred in the constellation *Picses*, which to the ancient astronomers was the constellation that foretold coming events. As the wise men rode into Bethlehem, the "Star of Bethlehem" was sinking into the western sky and appeared to scintillate. It is estimated that these movements among the

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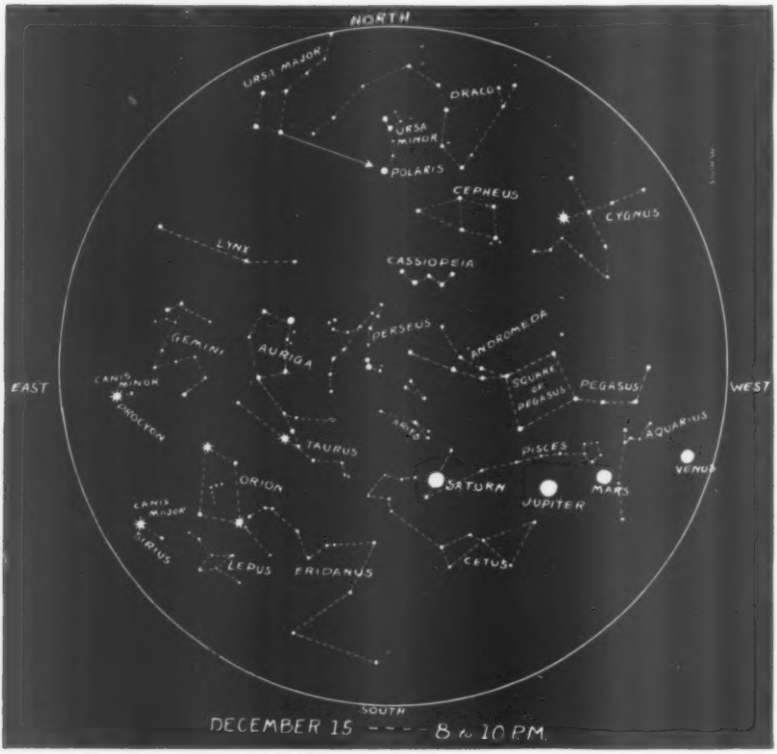
[2] Job, XXXVIII: 31, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion?"

[3] St. Matthew, II: 9, "When they heard the king, they departed; and lo, the star which they saw in the east, went before them, till it came and stood over where the young child was."

planets may occur about every 800 years, and the nearest date to the biblical narrative was 7 B.C. A year later, the planet *Mars* joined to make a celestial triumvirate that collaborate with the story often repeated and never forgotten. There is much speculation to explain the historical star, but the "conjunction theory" appears to be commonly accepted.

III. Classroom Activities[4]

The December sky offers unusual opportunity for making use of the scientific and legendary significance of the constellations, the stars, and especially the planets. Individual reports, drawings, clay models of the planets placed in the positions in small but representative orbits can add considerable classroom objectivity to understanding the December skies.



One activity fascinating to children is the "star box" equipped with a slip in the front and an electric light mounted inside. Constellation charts are easily made by plotting the maps on standard black or blue construction paper. If short strips of adhesive paper are punched, the gummed discs

[4] Some interesting science activities are compiled in "Practical Contributions on Science in the Grades" published by School Science and Mathematics, 3310 North 14 Street, Milwaukee, Wisconsin, 1939.

can be attached to the construction paper to represent the positions of the stars and planets. With this step completed, the discs are punched full of holes with a needle and a single needle-hole line can connect the stars to complete the constellation. When the chart is completed, the stars appear as they actually appear in the sky. When the chart is inserted in the star box and illuminated, the light shines through the chart, making the stars "twinkle" and appear in constellation form. The star box has been successfully used in various ways for class discussions and assembly programs. The many possibilities for the use of the star-box are obvious, and when the box is used in a dark room, children find their indoor observations a fascinating experience.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problems, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known reference to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1611. *Mr. and Mrs. Walter R. Warne, Rochester, N. Y.*

1612. *Alvin Mars, Brooklyn College.*

1616. *Proposed by C. W. Trigg, Los Angeles.*

Find the two permutations of the ten digits which are multiples of 1901 and are also perfect squares. Show that they are the only ones.

Solution by (author's name not given)

Any number composed of the ten digits 1, 2, 3, 4, 5, 6, 7, 8, 9, 0 is a multiple of nine.

Let N equal the number whose square is the permutation. Then N is a multiple of 3 and also of 1901 or N is a multiple of 5703.

Now N is not greater than the square root of 9876543210 or 99381 and N is not less than the square root of 1023456789 or 31991.

Therefore N is a multiple of 5713 between the numbers 99381 and 31991.

The first multiple of 5703 above 31991 is 34218. Hence, beginning with 34218 inspect the squares of the multiples of 5703 up to 95931.

There are only 11 such numbers. (57030 is omitted because of the final 0.)

$45624^2 = 2081549376$ and $91248^2 = 8326197504$ which are the two permutations sought.

Solutions were also offered by W. Brandt Hughes, Wilmore, Ky., Alan Wayne, New York City and the proposer.

1617. *Proposed by I. N. Warner, Platteville, Wis.*

How many one inch balls can be placed in a rectangular box which measures inside 5 in. by 10 in., with a depth of 10 in.

Solution by W. R. Smith, Suttons Bay, Mich.

If a layer of balls be placed on the bottom of the box in a rectangular position, there will be 50 balls in this layer. Nine such layers can be placed directly over these making in all 500 balls.

If the balls in the second layer are placed each over the point between four balls in the first layer, there will be 4×9 or 36 in this layer. If the box be then filled with alternate layers of 50 and 36 balls the total number of layers may be determined as follows. The height of the center of a ball in the second layer above the centers of the balls in the first layer equals the altitude of a square pyramid, each of the sides of the base being one inch. This altitude is .707. As the centers of the bottom layer are $\frac{1}{2}$ inch from the bottom and the centers of the top layer must be at least $\frac{1}{2}$ inch from the top, the total number of layers will be 1 plus $9 \div .707$ or 13 layers. Of these layers seven will contain 50 balls and six, 36 balls, making a total of 566 balls.

If a row of balls be placed along one edge of the bottom and the balls in the second row be placed opposite the points of tangency of the balls in the first row, there will be 9 balls in the second row. If the bottom be covered with alternate rows of 10 and 9 balls, the number of rows and the number of balls in the layer may be found as follows: The distance between a line through the centers of the first row and a line through the centers of the second row equals the altitude of an equilateral triangle each of whose sides is one inch. This altitude is .866. The number of rows will be $4 \div .866$ increased by one which is five. Three of these rows have 10 balls and the other two have 9 balls, making a total of 48 balls in the lower layer. If the box were filled by placing such layers directly over each other, we would have only 480 balls. If the balls of the first row of the second layer are placed directly over the point between two adjacent balls of the first row of the bottom layer and the tangent ball in the second row, there will be 9 balls in this row. Continuing in a similar manner, there will be 10 balls in the second row. The balls of the first row will be $.866 \div 3$ or .287 inches from the side of the box so there will be five rows in this layer. Of these five rows, three will have 9 balls while two will have 10 balls, making 47 in the second layer. The third layer will be directly over the first, the fourth over the second, etc. The height of each layer over the preceding is the altitude of a regular tetrahedron whose sides are one inch or .817 inches. The number of layers will then be $9 \div .817$ increased by one or 12 layers.

Of these twelve layers, six will have 48 balls and six will have 47 balls or a total of 570 balls.

EDITOR'S NOTE: In Mr. Smith's solution of this problem, he makes quite an extended analysis showing other methods of filling the box. However, he concludes that 570 is the largest number of one inch balls that can be placed in the box by any of the possibilities mentioned.

1618. *Proposed by Fred Marer, Los Angeles.*

Prove $\cot x/2^n - \cot x > n$ for $n > 0$ and $0 < x < \pi$.

Solution by David X. Gordon, Brooklyn, N. Y.

The half-angle formula for cotangent $x/2^n$ can be resolved into the forms

$$\cot x/2^n = \sqrt{\frac{1+\cos x/2^{n-1}}{1-\cos x/2^{n-1}}} = \frac{1+\cos x/2^{n-1}}{\sin x/2^{n-1}} = \csc x/2^{n-1} + \cot x/2^{n-1}.$$

By successive substitutions, for $\cot x/2^n$, we find

$$\cot x/2^n - \cot x = \csc x/2^{n-1} + \csc x/2^{n-2} + \cdots + \csc x + \cot x - \cot x.$$

Since $\csc x > 1$, $0 < x < \pi$, each term of this expression exceeds unity, so the sum of the n terms exceeds n.

Solutions were also offered by Malcolm Kirk, West Chester, Pa., Alan Wayne, New York City and the proposer.

1619. *Proposed by John P. Hoyt, Cornwall, N. Y.*

The equilateral triangle ABC is inscribed in a circle. Find a point, P, in arc AB such that chord PB is a mean proportional between chords PA and PC.

Solution by A. MacNeish, Chicago, Illinois.

Let D be the point which divides the radius OB into mean and extreme ratio. Call the radius, r; the larger section, m; and the smaller section, e. Then

$$\frac{r}{m} = \frac{m}{e}.$$

Construct the $\triangle A'P'B'$ with $A'P' = e$, $P'B' = m$, and the $\angle P' = 120°$.

In the given circle construct $\angle \alpha = \angle A'$, thereby determining point P on the arc AB. P is the required point.

Draw chords PC and PB. Call $\angle APC$, β, and $\angle BPC$, γ.

$\angle \beta = 60°$ being measured by $\frac{1}{2}\, AC$.

$\angle \gamma = 60°$ being measured by $\frac{1}{2}\, BC$.

Therefore $\angle APB = 120°$ and $\triangle APB$ is similar to $\triangle A'P'B'$.

Therefore

$$\frac{BP}{m} = \frac{AP}{e} = \frac{AB}{A'B'}$$

$$\frac{BP}{AP} = \frac{m}{e} \text{ from which } \frac{AP+BP}{BP} = \frac{m+e}{m}.$$

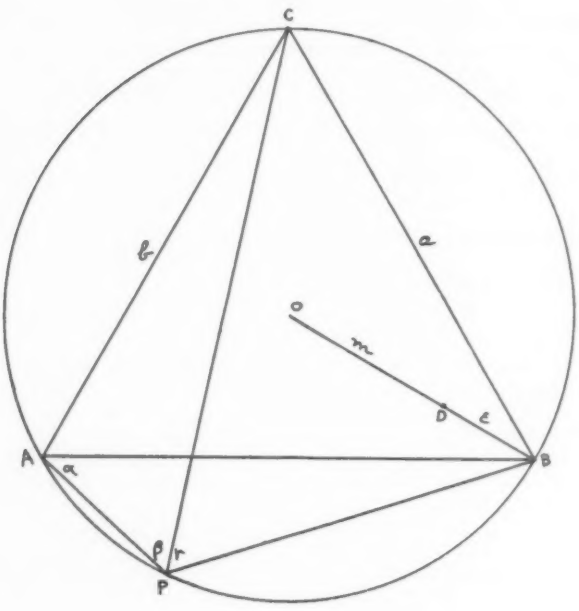
But

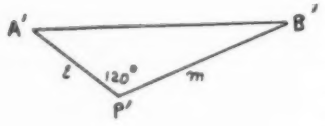
$$m+e = r. \text{ Therefore } \frac{AP+BP}{BP} = \frac{r}{m}.$$

In $\triangle APC$, $b^2 = AP^2 + PC^2 - 2AP \cdot PC \cdot \cos 60° = AP^2 + PC^2 - AP \cdot PC$.

In $\triangle CPB$, $a^2 = PB^2 + PC^2 - 2PB \cdot PC \cdot \cos 60° = PB^2 + PC^2 - PB \cdot PC$.
But $a^2 = b^2$ since $\triangle ABC$ is equilateral.
Therefore $AP^2 + PC^2 - AP \cdot PC = PB^2 + PC^2 - PB \cdot PC$

$$AP^2 - PB^2 = AP \cdot PC - PB \cdot PC$$
$$(AP + PB)(AP - PB) = PC(AP - PB)$$
$$AP + PB = PC.$$





By substitution

$$\frac{PC}{PB} = \frac{r}{m}. \quad \text{But} \quad \frac{r}{m} = \frac{m}{e} \quad \text{and} \quad \frac{PB}{AP} = \frac{m}{e}.$$

Therefore

$$\frac{PC}{PB} = \frac{PB}{AP}.$$

The chord PB is therefore a mean proportional between AP and PC and point P is the required point.

Solutions were offered by Aaron Buchman, Buffalo, New York; Alvin Mars, D. F. Wallace; T. A. Pickett, South Weymouth, Mass.; Brooklyn, N. Y.; M. Kirk, West Chester, Pa.; C. W. Trigg, Los Angeles City College; D. L. MacKay, New York; and the proposer.

1620. *Proposed by O. T. Snodgrass, Yankton, S. D.*

In a circle inscribe an angle of 30 degrees whose sides shall pass through two fixed points within the circle.

Solution by C. W. Trigg, Los Angeles City College.

Let the fixed points be A and B. On AB as a chord, construct, in the well-known manner, circles P and P' in whose major arcs angles of 30° may be inscribed. The intersections D, E, D' and E' of these circles with the given circle, O, are the points such that when chords are drawn from them through A and B, these chords will form angles of 30° inscribed in O. Hence there may be four, three, two, one, or no solutions, according as the points A and B are so located that the circles P and P' will both intersect circle O, one intersect while the other is tangent, both be tangent or one not intersect while the other does, one be tangent and the other not intersect, or neither intersect circle O.

Solutions were also offered by M. Kirk, West Chester, Pa.; W. R. Smith, Chicago, Ill.; Thomas A. Pickett, South Weymouth, Mass., Alvin Mars, Brooklyn, N. Y.

1621. *Proposed by David X. Gordon, Brooklyn, N. Y.*

Prove geometrically that, if $a^2+b^2=1$ and $x^2+y^2=1$. a, b, x, y, positive and real, $ax+by<1$.

Solution by D. F. Wallace

Since $a^2+b^2=1=x^2+y^2$ therefore a, b, x and y may be represented as sides of a quadrilateral inscribed in a circle whose diameter is equal to 1. There are two cases to be considered in one of which (Fig. 1) side a is opposite x and b is opposite y; and in the other (Fig. 2) a is adjacent to x and b is adjacent to y. In Fig. 2 BN and DM are perpendicular to AC. In both figures AC intersects BD, a diameter, at E. It is assumed that $a\neq b$ or $x\neq y$ so that AC cannot be a diameter.

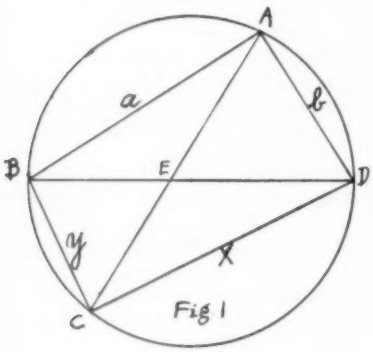


Fig 1

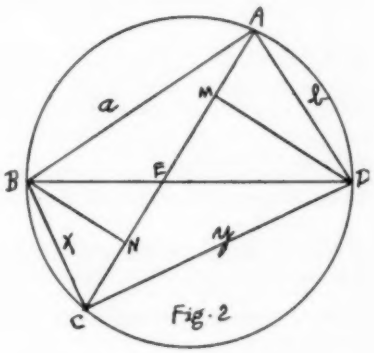


Fig. 2

In Fig. 1, $ax+by=BD\cdot AC=1\cdot AC$. (In a cyclic quadrilateral the product of the diagonals is equal to the sum of the products of the opposite sides.) AC is not a diameter and is less than 1. Hence $ax+by=AC<1$.

In Fig. 2, $ax+by=BN\cdot BD+DM\cdot BD=BN\cdot BD+DM\cdot BD$ $(BN+DM)BD=(BN+DM)1$. (In an inscribed triangle the product of two sides is equal to the product of the altitude on the third side and the diameter of the circle.) BE and ED are hypotenuses respectively of triangles BEN and DEN.

$\therefore BN < BE$ and $DM < ED$.
$\therefore BN + DM < BE + ED$ that is $BN + DM < BD$ or $BN + DM < 1$
$\therefore ax + by < 1$.

Solutions were also offered by Aaron Buchman, Buffalo, C. W. Trigg, Los Angeles, D. L. MacKay, New York and also by the proposer and M. Kirk, West Chester, Pa., Alvin Mars, Brooklyn, N. Y.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1620. Fred Doepsell and Donald Merres, North High, Sheboygan, Wis.

PROBLEMS FOR SOLUTION

1634. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Af a, b, c are the sides of triangle ABC, and if

$$c^2 = \frac{(a^2 - b^2)^2}{a^2 + b^2},$$

construct triangle ABC and find the relation between angle A and angle B.

1635. *Proposed by Dan Troutman, Va Lois, New York.*

Rationalize and reduce to as simple a form as possible

$$x^{1/5} + y^{1/5} + z^{1/5} = 0$$

where $(x + y + z) = 0$.

1636. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Prove that $\dfrac{72!}{(36!)^2} - 1$ is divisible by 73.

1637. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

In a variable triangle with a fixed base, the square of the altitude divided by the product of the segments into which the altitude divides the base equals a constant, k. Find the locus of the vertex and discuss this locus for various values of k.

1638. *Proposed by Maxwell Reade, Student at Brooklyn College, Brooklyn, N. Y.*

Can a triangle be constructed given H, I, O, where H is the orthocenter I is incenter, and O the circumcenter?

1639. *Proposed by Hugo Brandt, Chicago, Ill.*

Simplify

$$\operatorname{Sec}\beta \sqrt{\frac{1 - \sin^2\alpha \cdot \sin^2\beta}{1 + \cos^2\alpha \tan^2\beta}}.$$

Our job as educators is not to teach youngsters to become intellectual giants, but to send them out recognizing the privileges and obligations of society.—*George Chipperfield, President of the National Union of Teachers (England).*

SCIENCE QUESTIONS

December, 1939

Conducted by Franklin T. Jones

IMPORTANT QUESTIONS

What do you want in this Department?
(Tell the Editor and he will do his best.)
Should questions be aimed—
For Class Use?
For the Teacher?
For the Pupils?
For the General Reader?
Send in your "Do you know the Answer" Questions.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., S.E., Cleveland, Ohio.

JOIN THE GUILD OF QUESTION RAISERS AND ANSWERERS!

Over 300 different Contributors since October, 1934, have been elected members of the GQRA.

PATH OF A RIFLE BULLET

855. *Questions and answer by Carter Frank (GQRA, No. 267), Riverside High School, Buffalo, N. Y.*

Will a bullet fired from a gun barrel that is perfectly level rise above the muzzle of the gun as it appears to do in pictures of bullet flight trajectories?

Answer is "No." (See complete answer in the June, 1939, number of SCHOOL SCIENCE AND MATHEMATICS.

Comment by E. M. Tingley, Oak Park, Ill. (Elected to the GQRA, No. 296).

"See the book—*The Bullet's Flight From Powder to Target* by Mann.

"In some of the experiments the rifle barrels were made symmetrical around the axis of the bore so the recoil would be in line with the bore."

CULLED FROM THE ADVERTISEMENTS

869. *Proposed by Brother Felix John (GQRA, No. 17), Boys Catholic High School, Pittsburgh, Pa.*

Here are some science questions culled from the "ads":

1. LISTERINE TOOTH PASTE
   (1) What is a detergent?
   (2) What is the chemical formula for "Luster Foam?"

2. BŌST TOOTH PASTE
   (1) Explain the statement "Bōst dissolves coal tars!"

A PROTEST

One of our "Do You Know The Answer" Questions read: 42. "What is the most recently discovered vitamin?"

The Professor of Biology said, "XYZ."

Virginia Bryck, (Elected to the GQRA, No. 300) says: "The answer is not XYZ but K which was discovered by a laboratory technician in one of Milwaukee's brewery houses."

The Professor meant that new vitamins, or new organic catalysts if you want to think of them that way, are being discovered at frequent intervals and that we may soon exhaust the alphabet in naming them.

AN INTERESTING COMPARISON

870. *Adapted from figures supplied by Clark Bole, Cleveland, Ohio, (Elected to the GQRA, No. 297).*

The last ten years have shown "low water" in Lake Erie.

Opposite the mean height above sea level is set the rainfall at Cleveland for the years in question.

What do you think about the possibility of prophesying water level from rainfall? Why or why not?

Years	*Rainfall at Cleveland*	*Water level at Cleveland*
1929	+7.95 inches (+ above normal)	573.20 feet above
1930	−8.94 (− below normal)	573.05 sea level
1931	−4.48	571.20
1932	−0.62	571.29
1933	−9.65	571.10
1934	−12.01	569.99
1935	−4.37	570.24
1936	−6.80	570.49
1937	+4.50	571.57
1938	−2.39	571.65

(Average elevation of Lake Erie at Cleveland since 1900 is 571.87 feet above mean sea level. Also area of Lake Erie is 9,940 square miles; area of watershed, 34,680 square miles.)

Propose some questions based on the above data.

DO YOU KNOW THE ANSWERS?

You are invited to propose short questions with short and snappy answers for this section of SCIENCE QUESTIONS. *Ask your class to supply a set, or sets, of questions for publication. Credit will be given by membership in the GQRA.*

66. What is the fastest a human being has traveled?
67. Why does water run off a duck's back? (Helen Pirhofer, GQRA, No. 307.)

68. What is the fastest running animal? (Doris Gawronski, GQRA, No. 308.)
69. Why does a chameleon change colors? (Agnes McCorry, GQRA, No. 309.)

The other day I saw a "walking stick" on a green rose bush. He was green. Last summer I saw one on the trunk of a hickory tree. He was brown. Editor.]

70. What is the base of fine perfumes? (Dorothy Nierzwicki, GQRA, No. 311.)

Answers to 51–60, October SCIENCE QUESTIONS, *1939.*

51. The polar bear.
52. The humming bird.
53. The blue whale, which is known to attain a weight of 100 tons.
54. The alligator, also the crocodile.
55. The wolf.
56. The chimney swift.
57. The bison—their routes have been so perfect from an engineering standpoint.
58. The rabbit.
59. The opossum.
60. The white-tailed or Virginia deer.

THE "CUCKOO" BIRD TEST

865. *Submitted by Walter B. Juhnke, Manley H. S., Chicago, Ill. (GQRA, No. 291). Published in* SCIENCE QUESTIONS, *October, 1939. Answers in November, 1939.*)

Answers to individual questions in this test have been received from the following pupils of Mercy High School, Milwaukee, who are elected to the GQRA:

Margaret Starck, GQRA, No. 299; Jean Kane, GQRA, No. 302; Rita Kuzniewski, GQRA, No. 303; Donnorita Burke, GQRA, No. 304; Eva Spaeth, GQRA, No. 305; Jeanne Haessly, GQRA, No. 306; Elaine Fans, GQRA, No. 310.

MORE PROTESTS

44. Fish contains phosphorus. Phosphorus is reckoned a necessary constituent of the brain. Therefore, fish is a brainfood.

Is this good logic? (SCIENCE QUESTIONS, October, 1939).

Patricia Hayes (elected to the GQRA, No. 298) says:

"Literally fish is not a brainfood. Since phosphorus is a nerve food and the brain is the center of the nervous system, it is easy to see how such a false idea might arise."

Jacqueline Spors (elected to the GQRA, No. 301) says:

"Fish is no more a brain food than any other food that contains phosphorus."

ED. JONES'S LAMENT

"Getting Out Copy for SCIENCE QUESTIONS is no picnic:

"If we print jokes, people say we are silly; if we don't, they say we are too serious;

"If we clip things from other journals, we are too lazy to write them ourselves;
"If we don't, we are too fond of our own stuff;
"If we don't print contributions, we don't appreciate true genius;
"If we do print them, the magazine is filled with junk;
"If we make a change in the other person's write-up, we are too critical;
"If we don't, we are asleep;
"Now, like as not, someone will say, we swiped this. WE DID."

NEW MEMBERS—GQRA—December, 1939

296. E. M. Tingley, Oak Park, Illinois
297. Clark Bole, Cleveland, Ohio
298. Patricia Hayes
299. Margaret Starck
300. Virginia Bryck
301. Jacqueline Spors
302. Jean Kane
303. Rita Kuzniewski
304. Donnorita Burke
305. Eva Spaeth
306. Jeanne Haessly
307. Helen Pirhofer
308. Doris Gawronski
309. Agnes McCorry
310. Elaine Fans
311. Dorothy Nierzwicki
312. Mary Jane Wolf
313. Rosalie Zepirski

The above, 298 to 313, are all from Mercy High School Bio-ite Club, Milwaukee, Wisconsin.

JOIN THE GQRA!

BOOKS AND PAMPHLETS RECEIVED

Descriptive Geometry, by A. V. Millar, Assistant Dean, Professor of Drawing, College of Engineering, University of Wisconsin, and K. G. Shiels, Assistant Professor of Drawing, College of Engineering, University of Wisconsin. Cloth. Pages x+192. 14.5×22.5 cm. 1939. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.25.

A History of Chemistry, by F. J. Moore, Late Professor of Organic Chemistry in Massachusetts Institute of Technology; Revision Prepared by William T. Hall, Associate Professor of Analytical Chemistry in the Massachusetts Institute of Technology. Third Edition. Cloth. Pages xxi+447. 13.5×20.5 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.00.

Biology, by Brother H. Charles, Professor of Biology, St. Mary's College, Winona, Minnesota. Cloth. Pages viii+408. 13.5×21.5 cm. 1939. Bruce Publishing Company, Milwaukee, Wis. Price $1.72.

Intermediate Chemistry, by T. M. Lowry, Professor of Physical Chemistry in the University of Cambridge, and A. C. Cavell, Senior Science Master at Uppingham School. Second Edition. Cloth. Pages xvi+879. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.25.

The Pageant of Electricity, by Alfred P. Morgan. Illustrated. Cloth. Pages xxvi+363. 14×21.5 cm. 1939. D. Appleton-Century Company, 35 W. 32nd Street, New York, N. Y. Price $3.50.

First Course in Theory of Numbers, by Harry N. Wright, Associate Professor of Mathematics, The City College, New York. Cloth. Pages vii+108. 14×21.5 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.00.

Working with Nature, by Eleanor King and Wellmer Pessels. Cloth. Pages xv+181. 12.5×19 cm. 1939. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $1.20.

The Development of a Course in the Physical Sciences for the Senior High School of the Lincoln School of Teachers College, by H. Emmett Brown, Lincoln School, Teachers College, Columbia University. Cloth. Pages ix+205. 15×23 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $2.25.

Development of the Minkowski Geometry of Numbers, by Harris Hancock, University Station, Charlottesville, Virginia. Cloth. Pages xxiv+839. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $12.00.

The Dozen System An Easier Method of Arithmetic, by George S. Terry. Paper. 52 pages. 23.5×29.5 cm. 1939. George S. Terry, Main Street, Hingham, Mass.

Introduction to Experimental Cookery, by Edith H. Nason, Professor of Foods, Syracuse University. Cloth. Pages ix+317. 14×20.5 cm. 1939. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $2.95.

The Photographic Process, by Julian Ellis Mack, Assistant Professor of Physics, University of Wisconsin, and Miles J. Martin, Professor of Physics, Milwaukee Extension Center University of Wisconsin. Cloth. Pages xvii+586. 17.5×24 cm. 1939. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $5.00.

Handbook of Nature-Study, by Anna Botsford Comstock, Late Professor of Nature-Study in Cornell University. Twenty-fourth Edition. Cloth. Pages xx+937. 17.5×26 cm. 1939. Comstock Publishing Company, Inc., 124 Roberts Place, Ithaca, N. Y. Price $4.00.

A Bibliography of Nature-Study, by Eva L. Gordon, Cornell University. Reprinted from Anna Botsford Comstock's Handbook of Nature-Study. Twenty-fourth Edition. 46 pages. 17.5×26 cm. Comstock Publishing Company, Inc., 124 Roberts Place, Ithaca, N. Y. Price 25 cents.

Simplifying the Combinations of Subjects Assigned to High School Teachers, by Edward F. Potthoff, Educational Consultant in the Office of the Provost and Associate Professor of Education, University of Illinois, Urbana, Ill. Bulletin, No. 87, Vol. 36. 66 pages. 15×23 cm. 1939. Published by University of Illinois, Urbana, Ill.

Suggestions for Teaching Selected Material from the Field of Genetics, by Anita D. Laton, Assistant Professor of Education, University of California, and Edna W. Bailey, Associate Professor of Education, University of California. Monograph Number One. Paper. Pages viii+66. 15×23 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price 50 cents.

BOOK REVIEWS

Elements of Plant Pathology by Irving E. Melhus, Professor of Plant Pathology and Head of the Department of Botany and George C. Kent, Instructor in Plant Pathology both of Iowa State College. Cloth. 15 × 21.5 cm. Pages x+493. 242 figures consisting of photographs diagrams, maps and drawings of pathological tissues. Macmillan, New York. 1939. Price $4.00.

This book was definitely written to be used as a textbook. It is so designed that the interests of the teacher of botany, the farmer and the agriculturist are met. The objectives which the authors hope the text will help to achieve are: To appreciate the influence of plant pathology on man; To acquire an understanding of health and disease in plants; To understand the phenomenon of parasitism; To acquire as much information as possible about the characteristics of diseases, their symptoms, cause and control. The Chapter headings are: Introduction, Plant Pathology and Human Affairs, Development of Plant Pathology, Diseases in Plants, Parasitism, The Influence of Environment on Plant Diseases, The Principles of Control, Diseases Caused by Phycomycetes, Diseases Caused by Bacteria, Virus-Diseases of Plants, Diseases Caused by Ascomycetes, Diseases Caused by Fungi Imperfecti, Diseases Caused by Basidiomycetes Diseases Caused by Seed Plants, Diseases Caused by Plant Parasitic Nematodes, Diseases Caused by Non-parasitic Agents. A glossary, bibliography and index are appended. The section devoted to the viruses is particularly illuminating.

A. G. ZANDER

Visual Outline Of General Biology by George Child, Ph.D. of Amherst College. 13 × 20 cm. Paper. Pages iv+97. Longmans, Green and Co., New York.

The field of General Biology introductory in its nature is well covered by this outline. It should be of value to the beginner in this work in college. It gives the undergraduate a base for orientation in this work. The outline is divided into 7 parts viz: I—General Properties of Living Things. II—Nutrition. III—Irritability. IV—Reproduction. V—Heredity. VI—Evolution. VII—History of Biology. These parts are divided into 43 chapters. An appendix containing a good outline on classification, a reference list divided into sections for the different biological sciences and a good index.

A. G. ZANDER

Introduction to Atomic Physics, by Henry Semat, Assistant Professor of Physics, The City College of The College of the City of New York. Cloth. Pages xv+360. 14 × 21.5 cm. 1939. Farrar and Rinehart, Inc., New York, N. Y. Price $3.50.

This book presents the textual material for a one-semester undergraduate course in atomic physics. Because it presupposes only general physics and elementary calculus the author has outlined or given in full the mathematical development of the theory discussed except in those cases in which the theory is beyond the limitations of such a course. Sufficient description is included to give an understanding of the basic experimental investigations but emphasis is placed on analysis of the results of research. The author admits that some topics usually treated in such a course have been omitted in order to keep the text within the time limits for which it is designed. The most fundamental of these omissions is a treatment of black

body radiation. Since this was one of the "small clouds on the horizon" that grew into the storm of the new physics, failure to discuss the topic seems to be a serious omission. However, the clear and concise discussion of the topics chosen, the many helpful diagrams and half-tones, a few well-selected references and a list of problems for each chapter are features that will give the text a high rank among others in this field.

G. W. W.

The Nature of the Atom, by G. K. T. Conn. Cloth. 115 pages. 12×18.5 cm. 1939. Blackie and Son, Limited, 50 Old Bailey, London, E. C. 4. Price 3s. 6d. net.

It is hoped by the publishers that this book "will be found well fitted . . . to satisfy the natural curiosity of the ordinary intelligent person with regard to the interesting things in the newer physics." The author passes over the work of Dalton, Mendeleef, J. J. Thomson and others in a few pages, and the reader soon finds himself surrounded by scattered alpha particles, spectral series, and quanta. The brief review of atom models, the optical spectrum, quantum theory, and the Bohr postulates is an excellent summary of results of much intensive research, but it is doubtful if the ordinary intelligent person will grasp the significance of the discussion unless his education has included some serious study of physical science. If the reviewer has not erred in judgment thus far, it must be accepted at once that the reader not trained in modern physics will encounter considerable difficulty with the second half of the book which deals with quantum numbers, the interpretation of spectra, energy levels in the nucleus, and a classification of the elements based on atom structure rather than on chemical properties. Those who have had a start in the study of atomic and nuclear structure will be delighted with this book and it will stimulate others to more detailed and technical reading.

G. W. W.

German-English Science Dictionary for Students in the Agricultural, Biological and Physical Sciences, by Louis De Vries, Professor of Modern Languages, Iowa State College with the Collaboration of Members of the Graduate Faculty. Cloth. Pages x+473. 12.5×18 cm. 1939. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.00.

The author of this dictionary acknowledges the active assistance of thirty-four members of the graduate faculty from all science departments of Iowa State College. This has resulted in a dictionary sufficiently complete to serve the more frequent needs of students in all the sciences. To cover so large a field it was necessary to limit the number of compound words listed and encourage the student to learn to analyze such words into their root stems. The use of this dictionary thus requires a more basic knowledge of the German than is demanded by some of the dictionaries prepared for specific sciences. From the fields of science represented by the collaborators one would expect to find the dictionary better adapted to work in the biological sciences than in the physical science, but the reviewer found it quite sufficient for reading German textbooks of classical physics.

G. W. W.

America Begins Again, by Katherine Glover. Cloth. Pages xv+382. 13.5×20.5 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.76.

One of the greatest sins of the American people is waste, especially waste and destruction of our natural resources. Much of this destruction has been wrought by greed but a large part is due to ignorance. This book calls attention to the depletion of our soil, forests, minerals, and wild life and describes the steps being taken to prevent further waste and to restore some of the lands and waters to their original state of productivity. The book is well designed for supplementary reading in the grades but is interesting alike to adults. Unfortunately the reliability of the book is marred by a number of incorrect and unscientific expressions; e.g., on page 93 we read: "The elements—ether, air, fire, water, and the earth's minerals—are said to be the schoolmasters, or the disciplinarians, of men." And again on page 136: "The upper basin [of the Colorado River] enclosed by mountains, has rich deposits of ore: 75 per cent of the silver, 80 per cent of the copper in the country, as well as rich deposits of zinc, lead, and gold are to be found there." But the merits of the book greatly overbalance these blunders and assure it a place of usefulness in a field where there is great need.

G. W. W.

Engineering Descriptive Geometry, by Charles Elmer Rowe, B.S. (C.E.), E.M., Professor of Drawing, University of Texas. Cloth. Pages viii +299. 15.5 × 23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y.

The author, feeling that the "direct method" has distinct advantages over the older "Mongean method" presents the subject without the use of ground lines, folding lines, traces of planes, or similar devices. Pointing out the fact that the draftsman often is presenting an object of his creative imagination and hence cannot determine by actual observation which edges are visible, the author presents definite rules which give a systematic method of determining visibility. One chapter is devoted to the Mongean method, and another devotes considerable time to shades and shadows. A chapter on geology and mining problems and another on engineering problems should go far toward the goal of pointing out to the student a practical use of the subject matter. A brief historical summary is presented in the introduction.

The arrangement of the material on the page gives a pleasing impression; the typography is excellent, one trivial misprint was noted on page 174. The supply of problem assignments seems ample.

CECIL B. READ, *University of Wichita*

Differential and Integral Calculus, by John Haven Neelley, Ph.D., Professor of Mathematics in The Carnegie Institute of Technology, and Joshua Irving Tracey, Ph.D., Associate Professor of Mathematics in Yale University. Second Edition. Cloth. Pages ix+495. 14.5 × 22 cm. 1939. The Macmillan Company, New York, N. Y. Price $3.25.

This is a second edition of a calculus text which many instructors have found eminently satisfactory, the first edition being noteworthy for the excellent manner in which the applications of calculus to varied fields were shown. As far as the presentation of subject matter is concerned, changed material in the second edition seems relatively minor. The chapter on solid analytic geometry has been slightly expanded; in the next chapter there has been added a brief discussion of one or two topics not covered in the first edition. There have been a few changes in the order of presentation, again of minor importance. The problems, however, have been almost en-

tirely changed, with supplementary lists added. They seem carefully selected and graded, with a more abundant supply of simpler problems than was found previously.

In one or two places minor improvements were made, for example the text now speaks of the *force* exerted on a submerged surface rather than the incorrect term *total pressure;* the interval of definition of the principal value for the inverse secant and cosecant is now clarified. On the other hand, it would seem the formulas given in what is now problem 33 on page 409 still contain a couple of misprints.

The instructor who was well pleased with the first edition will be glad to find this edition with its new problems, for fraternity files will by this time have solutions to many in the old text; the changes which have been made will probably not be radical enough to induce one who was dissatisfied with the first edition to adopt the second edition as a text.

CECIL B. READ, *University of Wichita*

Mathematics of Statistics, by John F. Kenney, Northwestern University. Part One. Cloth. Pages x+248. 16×23 cm. 1939. Price $2.50. Part Two. Cloth. Pages x+202. 16×23 cm. 1939. Price $2.25. D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y.

Part One is an elementary text in mathematical statistics, very distinctly it is not a book from which the student merely learns to compute a few statistical measures with little or no knowledge of the underlying assumptions. The author wisely states that although one might profitably read the text with no mathematics beyond college algebra only the best students with this minimum preparation should attempt to study the text. Several optional problems are provided for those who have a knowledge of calculus.

The material covered is indicated by the chapter headings: frequency distributions, graphical representation, averages, moments, measures of dispersion, types of distributions and the normal curve, curve fitting, and correlation theory. The author feels that the theory of sampling cannot be taught satisfactorily at the level of Part One and devotes a major portion of Part Two to this topic. There is no discussion of the sources of data, in fact the major portion of the data furnished for illustrative examples and for exercises, has nothing to show its source. There is an ample supply of exercises, well graded as to difficulty, some of the harder ones will challenge the ability of the better students.

Part Two covers some of the material of mathematical statistics which requires more powerful mathematical tools; the student will probably need advanced calculus for a satisfactory reading. Among many other topics are included probability, Gamma and Beta functions, the Gram-Charlier series, the normal correlation surface, multiple and partial correlation, Bayes' Theorem.

Both parts are exceptionally valuable on account of the many references for supplementary material on the topics covered, including not only pertinent books, but also recently published papers by recognized authorities.

A few minor details may not appeal to all instructors. In Part One in particular there is a tendency to introduce a topic with rather brief discussion, stating that fuller discussion will follow later. This may be repeated to an extent that the student wonders when it will cease. The treatment of frequency distributions does not point out alternative methods of presenting data, and may leave the student confused when he encounters such methods. The calculus student may quibble over the statement: 'the area under $f(x)$ between a and b is called the integral of $f(x)$ from a to

b"; or the conclusion that if two curves are parallel on ratio paper their rate of increase is the same (this does not agree with his calculus concept of rate of increase).

Part One should be a very teachable text in a course in mathematical statistics; both parts will be a valuable addition to the reference texts available in any statistics department.

CECIL B. READ, *University of Wichita*

Engineering Drawing, by H. H. Winstanley, B. Sc. Eng., A. M. I. Mech. E., Lecturer in Mechanical Engineering, Wigan and District Mining and Technical College, Wigan, England. 1st Edition. Pages iv+128. 292 Drawings. 22.5×28.5 cm. 1939. Cloth. List Price $1.60. Edward Arnold & Company, London, England.

As the prefatory note indicates this book is intended to cover the normal syllabuses of the First and Second Year National Certificate Courses in Engineering Drawing, and to meet the requirements of students in Senior First Year Full-Time Classes in Technical Colleges. It follows the recommendations of the British Standards Institution on Drawing Office Practice and such conventions in average use not covered by the former.

There is a modicum of written description in order to have place for more pictured problem material. The latter is generally presented in the projected form rather than the pictorial as is usually found in American texts. The book makes consistent use of first angle projection that is so prevalent in European Engineering Drawing in contrast to third angle projection, so predominant in American practice.

The mechanics of drafting and lettering have been purposely omitted. Topics like Graphs, Shading, Patent Office Drawing, Topographic Drawing, and Welding that are a part of the average American text in this field are lacking. The subject matter is progressive in arrangement, well selected, delineated with professional skill, and scaled to promote rapid visual comprehension.

LUMIR P. BRAZDA, *Wilson Junior College, Chicago*

College Algebra, by Paul K. Rees, Assistant Professor of Mathematics, New Mexico State College of Agriculture and Mechanic Arts, and Fred W. Sparks, Professor of Mathematics, Texas Technological College. 1939. 16×24 cm. xi+312 pages. McGraw-Hill Book Company, Inc., New York. Price $2.25.

One outstanding feature of the book is the manner in which the authors have provided for review of previously learned algebra. Instead of placing all review materials at the beginning of the course, they have presented it a part at a time in connection with the topics for which the particular part of the review is most needed. This insures that the ideas will be fresh in mind when they are needed and also makes the student realize that no previous knowledge can be discarded at any time. The authors have held to the language with which the student is familiar from his secondary mathematics so that he will not seem to have gotten into an entirely different field. There is sufficient explanation, and yet the book is not top-heavy on theory. New ideas are illustrated in worked examples so that the student can see exactly how they are used. Some of the topics treated are Horner's Method, The Binomial Theorem, Theory of Determinants, Permutations and Combinations, Probability, etc. Answers are given for half the exercises.

WALTER CARNAHAN, *Shortridge High School, Indianapolis*

Coordinate Geometry, by Luther Pfahler Eisenhart, Professor of Mathematics, Princeton University. 1939. 15×21.5 cm. xii+288 pages. Ginn and Company, New York.

This is an unusual geometry in its plan of organization and in the placement of emphases. The concepts of Solid Analytics are presented early and integrated with those of Plane Analytics. Direction numbers and direction cosines are introduced on page 11 as applied to the plane which makes it easy to handle these ideas when they are met in Solid Analytics. Parametric equations of the line are introduced on page 20. Space coordinates are presented on page 76. Spherical and cylindrical coordinates are used. The author makes extensive use of determinants and develops the theorems needed in their manipulation. An unusual feature is the treatment of elipses and hyperbolas together, in a number of pages, parallel columns being used to show the likeness of these two curves. The subject of asymptotes is presented relatively late in the course but is given complete treatment; horizontal and vertical asymptotes are not treated separately. The book is theoretically more complete and full than is usual, but there are sufficient problems to give plenty of practice to the student.

WALTER CARNAHAN

Business Arithmetic for College Students, by William S. Schlauch, School of Commerce, Accounts and Finance, New York University. First edition 1939. 16×23.5 cm. vii+299 pages. F. S. Crofts and Company, New York. Price $2.80.

This text makes more use than is customary of mathematics other than arithmetic. The number system is described in detail, signed numbers are explained, logarithms are treated, graphs and the metric system are included. And the author makes constant use of these ideas throughout the book. Numerical examples are used to make clear a new subject or idea, then there is a formal statement of the facts taught, and finally a formula where it is possible to give one. This presents new ideas in the way in which it is easiest for the learner to grasp them. Methods of calculation used in business houses are taught. The book is not too difficult for the average college freshman, and yet there is an abundance of problem materials. Some of the subjects taught are compound interest, depreciation calculation, installment buying (with a method given for estimating the effective interest rate on deferred payments), corporate securities, mark-up etc. No answers are given to the problems.

WALTER CARNAHAN

Practical Shop Mathematics, by John H. Wolfe, Supervisor of Apprentice School, Ford Motor Company, and Everett R. Phelps, Ph.D., Associate Professor of Physics, Wayne University. Revised edition. 1939. 13×20.5 cm. Volume I (Elementary) xiv+349 pages. Volume II (Advanced) xiv+318 pages. Cloth. McGraw-Hill Book Company, Inc., New York.

The materials included in these books were used for several years in The Apprentice School of The Ford Motor Company, then published as texts in 1935, and now revised. Mr. Wolfe had a number of years shop experience before being connected with the Apprentice School, and the books bear evidence on every page of his wealth of experience and his practical point of view. Theoretical discussions and developments are reduced to a minimum, and the problems are lifted right out of the shops. The revision presents an improved organization of certain parts and substitutes simpler problems for some that have been found too hard. Enough arithmetic, al-

gebra, geometry and trigonometry are presented to make it possible for the student to solve the problems, but there is no claim to completeness in these subjects. Answers are given to a few problems.

Volume I presents the needed fundamentals of arithmetic, algebra, geometry and trigonometry with much drill and many practical problems. Volume II presents some necessary problems from spherical trigonometry and treats of many applications in more advanced practice.

The fifty propositions are rigorously proved which one hardly expects in a work of this nature. As the authors explain, this is to make sure that "the training value of rigorous proofs may not be lost."

WALTER CARNAHAN

MOTION PICTURE REVIEWS

Liquid Air. Ufa Films, Inc., 729 Seventh Ave., New York City. 16 or 35 mm., silent or sound. 1 reel.

I. The Story of the Film.

The film begins with an attempt to make clear the very low temperature at which liquid air boils (−190°C.), a temperature far below any which we personally experience. This temperature is so low that it may be referred to a new scale with a zero at − 73°C., a temperature at which all molecular motion ceases, the true absolute zero. But air is a mixture, so the various components boil off at their own particular temperatures. Following some simple experiments designed to show how low temperatures are produced, we are given some idea of how liquid air is produced. Then follow a number of experiments which show its properties. Eggs, flowers, rubber are frozen to a brittle hardness; a lead bell becomes resonant, mercury freezes. Since nitrogen boils off before oxygen, after liquid air stands for a time it becomes nearly pure liquid oxygen. This latter substance is used for a number of experiments. In spite of its great coldness many substances, e.g., iron, burn in it. Other experiments suggest that charcoal, soaked in liquid air becomes an explosive and show the magnetic properties of the liquid. Final experiments show the even lower temperatures to be obtained from other gases of the atmosphere—neon at +246°C., hydrogen at −253°C., a temperature so low that when a heavy metal ball is immersed in it for a time and then suspended in the air, liquid air runs from its surface like water, and helium at −269°C.

II. Criticism of the Film as a Teaching Aid.

The reviewing committee felt that this film would be excellent for use in general science, physics and chemistry courses and in the beginning years of college. Accurate in every respect with one minor exception where it was not made clear that cooling by evaporation does not function equally well under all conditions, the film's main weak point lies in the fact that it does not more completely relate the phenomena presented to molecular theories of heat. Hence its main value would be as a basis for initiating new work, arousing interest and making clear the meaning of the absolute scale. For these purposes the film is excellent.

III. Technical Qualities of the Film.

The photography in this film is superior and the sound quality of the film track exceptionally good. Animation could have been employed at certain places to make the molecular motions suggested in the commentary quite clear and explicit. The committee was in agreement that the use of sound greatly enhanced the quality of the film.

IV. Rating.

1. Age level; of interest at all ages from junior high school to adults.
2. Quality of photography: excellent.
3. Selection of scenes: generally good. Needs animation of molecular motion as explained above.
4. Quality of narration: Excellent. No musical background to distract.

Craters of the Moon. Bell and Howell Co., 1801 Larchmont Ave., Chicago, Ill. 1 reel, 16 mm., sound. 9 minutes.

I. The Story of the Film.

The film opens with a picture of a large astronomical telescope and then shows the craters and mountains of the moon as they would appear through such a telescope. The possibility of a trip to the moon by rocket ship is then discussed and, from this point on, one is to imagine that they are observing a party of explorers who have made this trip and are finding their way over the moon's surface. The scenes are taken in various volcanic regions and show well the various features of vulcanism on our own planet. An eruptive type is shown and a very good shot of quiet lava flow, showing the ropey surface of the hardened rock.

The group of explorers are seen climbing a cinder cone and the difficulties encountered are described. Some very good shots are shown of caves in hardened lava and the desolate character of the country is well depicted. At the end of the film, it is explained that what has been seen was, of course our own earth but that the region photographed is similar to that which would meet the eye of an explorer on the moon.

II. Criticisms of the Film as a Teaching Aid.

The criticisms of the committee are mainly directed against the title. The film has made a valuable contribution to the study of volcanic action. From the title one would infer that volcanoes are actually present on the moon and that there is no doubt but that the irregularities of the moon's surface are due to just that kind of action. Although the scientific possibilities of reaching the moon by rocket were discussed, there was no suggestion of how men could walk around on its surface without special equipment for breathing. As a theatrical film the film is probably suitable in its present form. For classroom use it should be recaptioned for the special purpose for which it is adapted—an interesting film dealing with volcanic action.

III. Technical Qualities of the Film.

Technically the film is well done. The photography is exceptionally clear the commentary, with the exceptions noted, satisfactory and accurate.

IV. Rating.

1. Age level—Junior and Senior High School.
2. Quality of photography—Excellent.
3. Selection of scenes—Fair.
4. Quality of sound—Good.
5. Teaching Value—Moderate, because of possibility of confusion.

The Life History of the Garden Spider. Edited Pictures System, Inc., 330 West 42nd St., New York City. 11 minutes.

I. The Story.

The film illustrates the life and habits of some of the common spiders

found around the garden. It shows how the spider spins his web and catches his prey. The illustractions of the ways in which he fastens them to his web and how they are paralyzed is very interesting. The story of the survival of the fittest is quite evident in this film as shown in the successive steps of the spider catching and devouring his prey and he in turn being eaten by larger animals of the garden.

II. Criticism of the Film as a Teaching Agent.

This film is a very effective aid in showing how smaller animals live and struggle for survival. The degree of interest for any group is very high. This picture is highly recommended for use by either intermediate group or Junior or Senior High School groups. It is an explanatory film quite detailed and is complete in all details leaving no gaps to be filled in.

III. Technical Qualities of Film.

The technical qualities are very good, the scenes were very clear and the sound quality was excellent. The narrator gave a very clear concise picture of the life of the garden spider. The animated drawings were good, but an animation of the functioning of the spinnerets should have been put into this picture. The film was as accurate as one of this type could be and it was complete in all respects. This film was greatly enhanced by the use of sound. A silent film with captions would not have been as satisfactory.

IV. Rating.

This picture is high for any group because of the manner in which it is presented and because of the wide range teaching purposes. It should be very highly recommended.

Plant Power. Ufa Films, Inc., 729 Seventh Avenue, New York, N. Y. A 16 or 35 mm. film silent or sound. 1 reel.

I. The Story of the Film.

Plant power shows dramatically the force exerted by growing plants. This is done by the use of time lapse photography and by use of some photomicrographs. It further shows the structural strength of stems which withstood strong winds and the struggle of a parasitic plant in conquering its host.

First scenes show the opening of a sunflower. Then views of several plant swaying in the wind together with sections of their stems are shown. An experiment effectively shows how a bast fiber breaks only after continued pressure while a copper wire of equal tensile strength breaks immediately.

Scenes then show vines attaching and supporting themselves by twining and by tendrils.

A tall tree is then shown and two experiments are made in an attempt to answer the question of how 150 quarts of water are raised to the top daily.

Several unusual scenes which can only be seen by the use of time lapse photography follow. Young radish plants, sunflowers, lilies of the valley, and others show unbelievable strength in lifting soil, rocks, glass plates, etc. Lily of the valley stems break through five sheets of tinfoil.

A struggle is portrayed between the dodder and a young willow tree. The twisting motion of the young dodder stems, the contact with the willow, the twining around the willow, and the embedding in the stem are clearly shown. The willow finally succumbs to the parasite.

II. Criticism of the Film as a Teaching Aid.

The film makes a valuable contribution to the learning experiences of pupils from the junior high school level on up, because it shows by means of time lapse photography motions of plants not otherwise visible. The story of growth as told is fascinating in itself. It also stimulates investigation of physiological processes, of structure of plants, and of interrelations that exist among them. It should be highly recommended for use in classes studying plants, physiological processes, and ecology.

III. Technical Qualities of the Film.

The scenes are well chosen and well executed. One misses a known scale when viewing some of the close views highly magnified. The title does not clearly indicate the nature of the film nor are the captions on the silent version sufficient. Sound should help greatly in understanding many of the scenes. Not all of the questions raised were answered, for example, rise of water in trees. On the whole the film is very useful.

IV. Rating.

1. Age level: Junior High School and upward.
2. Quality of photography: Excellent.
3. Selection of scenes: Very good.
4. Sound: Believe preferable to silent version.

Reviewing committee
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A NEW MATHEMATICAL JOURNAL

A new international journal, to be known as "Mathematical Reviews," will be launched at Brown University this year under the sponsorship of the American Mathematical Society, with the support of other learned and philanthropic organizations.

Announcement of the journal's forthcoming publication was made by President Henry M. Wriston of Brown at the fourth annual Alumni Day dinner at Crescent Park. Hundreds of graduates were gathered to hear the president outline the university's progress, especially on its educational front.

Hailing the new venture as one which will "make Brown an even more important center for mathematics than heretofore," President Wriston also announced that the Rockefeller Foundation has granted the university $49,500 for a micro-film laboratory to be set up in connection with the new journal and Brown's distinctive mathematics library.

He said that a new international journal is needed because the German publication, "Zentralblatt für Mathematik," has been influenced politically by the German Government. The United States and Canada, he added, are contributing more and more to mathematical research.

Prof. Otto E. Neugebauer, former editor of the German publication, has been appointed to Brown's staff and will edit the new "Mathematical Reviews," together with Prof. J. D. Tamarkin of Brown. Dr. Will Feller of Brown will be assistant editor.

Designed to "review all fields of pure mathematics," the new journal

will be published regularly in four languages—English, French, German, and Italian. The publication is expected to be a clearing-house of information for teachers and research workers in all parts of the world.

The Carnegie Corporation has appropriated $60,000 as a backlog for the new journal, according to Dean Roland G. D. Richardson of Brown's Graduate School, who is secretary of the American Mathematical Society. The Rockefeller Foundation has pledged $12,000. The American Mathematical Society and the Mathematical Association of American have given $1,000 each, he said.

The micro-film laboratory will be used to copy rare mathematical material for Brown's mathematics library, already recognized as one of the most complete in the world. Film copies of out-of-print journals and other publications will be available to mathematicians throughout the world. Films of any article reviewed in the new journal will be sent to subscribers at cost.

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